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INVESTMENT AND CASH FLOW: EMPIRICAL STUDY USING PANEL DATA FROM US MANUFACTURING INDUSTRY

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MA in Finance and Investment

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ABSTRACT

This study aims to illustrate the investment-cash flow sensitivity of constrained and unconstrained firms. Using data from 2,233 US manufacturing firms over 1999 to 2008, several findings present. Firstly, cash flow is found to significantly affect firm's investment behaviour. Secondly, when firms are labelled as constrained and unconstrained by dividend and firm size dummy, unconstrained firms are found more sensitive if the sample is split by dividend dummy. Meanwhile, the result is reversed if firms in the sample are separated by firm size. Finally, the research on splitting firms by the two criterions interacted reveals that regardless of firm size, high dividend payers are always more sensitive. Similarly, for firms at identical dividend payment level, small firms are more sensitive.

Several econometric techniques are employed to generate the above results. OLS, fixed-effect model, first-differencing transformation and instrumental variables by GMM are utilized to test the significance of cash flow on investment. For the test of constrained and unconstrained firms, fixed-effect and instrumental variables by GMM are employed. However, GMM is found to exhibit weak estimation power.

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CHAPTER Ⅰ INTRODUCTION

1.1 General Background

Companies make investment decisions in seeking for better business opportunities and future development. In the early days, investment decisions are considered irrelevant to financial status. Modigliani and Miller (1958) demonstrated this by assuming perfect and complete capital market, in which transaction cost and taxes are absence. However, in the real world, perfect and complete capital market does not exist. Information asymmetry and agency costs make the choice of financial decisions complicated. Internal and external capital cannot substitute each other perfectly. In theory, external capital is believed to be much more costly than internal funds. Researches carried out by Greenwald, Stiglitz, and Weiss (1984), Myers and Majluf (1984), and Myers (1984) have exposed the problem of information asymmetry in capital market. Meanwhile, Bernanke and Gertler (1989) and Gertler (1992) demonstrated the impact of agency costs which add cost premium to external capital. All those studies show that external finance is more expensive than internal finance. Therefore, firms' investment decisions are constrained by the availability of relatively cheaper internal capital. By contrast, firms who are capable to undertake the higher cost and thus have access both to internal funds and external capital, are considered as financially unconstrained.

In their influential work, Fazzari, Hubbard and Petersen (1988) proved that financially constrained firms are more sensitive to internal cash flow than unconstrained ones. The study groups firms by dividend payout ratio. Firms who pay low dividends are considered as constrained because they retain most of cash inflow for investment and thus indicate that they have limited access to expensive external capital. Other researches have found similar relationship between investment and cash flow. For example, Hoshi, Kashyap, and Scharfstein (1991) on group membership of Japanese companies, Gilchrist and Himmelberg (1995) on firms accessing to commercial paper and bond market, and Kadapakkam, Kumar and Riddick (1998) on firm size. However, Kaplan and Zingales (1997) proposed challenge to Fazzari *et al*'s findings. Based on quantitative and qualitative information from firms' annual reports, they found that unconstrained firms appear as more sensitive to cash flow. The debate raises the issue that the choice of measurement to financial constraints makes tremendous difference on the outcome. Subsequent studies have addressed the problem of financial constraints, and find dissimilar results even for tests on the same sample but different financial constraints, such as Moyen (2004) and Almeida, Campello, and Weisbach (2004).

1.2 Introduction to This Study

This study tries to address several basic questions on the investment cash flow debate. Firstly, does internal finance, which is estimated by cash flow, significantly affect investment decisions? Almost all the literatures give positive answer to this question. This study is expected to provide further empirical evidence. In order to minimize factitious error, four econometric techniques are employed to process the research, including simple OLS, fixed-effect (within) estimator, first-differencing transformation and instrumental variables by Generalized Method of Moments (GMM). Prerequisite conditions for each method are examined for the validity of estimated coefficients, making sure that there is no bias or inconsistence in the outcome. Secondly, as previous literatures show different magnitude of sensitivity for constrained and unconstrained firms, this study split firms into the two groups by two criterions, which are dividend and firm size. These two are the most widely used and accepted standard to separate companies. Firm size is identified by total assets and sales. Unlike other researches, this study does not test the two sub-samples independently. Instead, dummy variables are created to label firms from different groups. An advantage of using dummy variable is that it conveniences the regression process. It is not necessary to run regression model twice for different groups of data (Karafiath 1988). In addition, Schiantarelli (1996) also suggested using dummy variables to control financial constraints. To test the sensitivity for constrained and unconstrained group, fixed-effect estimator and instrumental variable by GMM will be employed as the test technique. Thirdly, results for different splitting criterions will be compared, in order to address the effect of different measurement of financial constraints on investment-cash flow sensitivity. Additional to dividend dummy and firm size dummy, this study provides a new splitting method by interacting the two dummy variables together, as Schiantarelli (1996) claimed that dividing firms by one criterion may not be sufficient. The test will be carried out by fixed-effect model and GMM as well.

Before making empirical tests, previous literatures will be generally reviewed to build theoretical basis. Firms' decisions on financing investments by internal or external capital will be reviewed first. In Modigliani and Miller's world, there is no difference between internal and external finance. However, Myers (1984) challenged the theory by putting forward pecking order theory, of which information asymmetry is the major concern. He believed that firms choose to finance their investments by financial hierarchy. External finance, due to information asymmetry and thus more expensive, is the last option for financing.

Myers' argument emphasized the divergent ways of financing and stimulated the study of investment-cash flow sensitivity. There are many models to study such relationship, including neoclassical model and the most widely used model in recent studies, Tobin's Q model. The major debate for Tobin's Q model comes from financial constraints and calculation of Q. These will be discussed in detail in the literature review part.

1.3 Layout of This Study

The remainder of this paper will be allocated as follows. Chapter Ⅱ will be reviewing previous literatures on the issues discussed above, internal finance versus external finance, neoclassical model versus Tobin's Q model, as well as the arguments on financial constraints and Tobin's Q. In Chapter Ⅲ, detailed methodology for empirical tests will present, including variables to be used in the tests, the calculation of variables, models to be tested, and econometric techniques to be employed. Chapter Ⅳ contains data information and regression results from the regression tests, as well as discussion of the outcome obtained and limitations for the research. The final chapter, Chapter Ⅴ concludes the entire work.

CHAPTER Ⅱ LITERATURE REVIEW

2.1 Trade-off between Internal and External Finance

2.1.1 MM Theory

Since the 60s of last century, capital and investment has long been discussed by many researchers and scholars. An early work by Miller and Modigliani (1958) proved that a company's cost of capital was irrelevant to its capital structure (also known as MM Proposition Ⅰ). It is equal to the cost of capital as if the firm is solely financed by equity. An implication of their finds for investment decision is that "the cut-off point for investment in the firm will in all cases be ρ_k and will be completely unaffected by the type of security used to finance the investment (Miller and Modigliani 1958, p. 288)", where ρ_k can be interpreted as equivalent to the cost of equity of an unleveraged firm. In other words, Miller and Modigliani suggest that firms can finance their investments by any source. Internal or external funds do not make a difference. The decision is irrelevant to financial conditions.

MM theory is derived based on some crucial assumptions. Pike and Neale (2006) conclude some key assumptions as follows. First of all, all investors are price-takers and rational. No one is capable to influence the market price. Secondly, all the participants can lend or borrow at the same risk-free rate. Furthermore, there are no transaction costs and no taxes, for instance personal and corporate income tax. Additionally, firms are grouped into different "risk classes". For all firms in each of the groups, the market seeks for the same return. Firms cannot make any investment at the risk beyond or below the risk class. In general, MM theory will only apply in a perfect capital market which, in reality, is not the case.

2.1.2 Pecking Order Theory

In the 1980s, Myers and Majluf (1984) present another theory to explain capital structure which in Myers (1984) is referred to as pecking order theory. Their discussion takes information asymmetry into consideration, which means managers have superior information than investors, which does apply in real life. Myers and Majluf (1984) reported several strategies that firms employ to finance favourable investment. They prefer safer securities than risky ones, which imply that bond market is the wise choice when seeking for external finance. In addition, if the company has run out of cash or the cash flow is not sufficient to support the investment, the company, for the existing shareholders' interest, may choose to give up the opportunity rather than raising external funds. Thirdly, it is the firms' choice to cut back dividend in order to reserve for future investment. An alternative way to accumulate cash is by issuing equity at the period when manager's information advantage is at minimum level. Finally, firm should not pay dividend if it has to sell equity or other risky securities to generate cash. However, Myers and Majluf (1984) failed to present optimal issue strategy. Other researchers also have found evidence that companies prefer internal funds to external funds when financing an investment (Gertner, Scharfstein and Stein 1994, Oliner and Rudebusch 1992).

In his solely authored paper, Myers (1984) summarized pecking order theory as follows: (Myers 1984, p. 581)

- *"Firms prefer internal finance.*
- *They adapt their target dividend payout ratios to their investment opportunities, although dividends are sticky and target payout ratios are*

only gradually adjusted to shifts in the extent of valuable investment opportunities.

- *Sticky dividend policies, plus unpredictable fluctuations in profitability and investment opportunities, mean that internally-generated cash flow may be more or less than investment outlays. If it is less, the firm first draws down its cash balance or marketable securities portfolio.*
- *If external finance is required, firms issue the safest security first. That is, they start with debt, then possibly hybrid securities such as convertible bonds, then perhaps equity as a last resort."*

The pecking order theory is derived based on some assumptions as well. As Myers and Majluf (1984) stated clearly, due to the cost of information transmission, managers has information that is not released to investors, which makes managers obtain an information advantage. Secondly, firms are assumed to have one asset and one opportunity to invest. The project requires the firm to invest all or otherwise zero. The firm cannot invest in part of the project. Furthermore, capital market is assumed to be perfect and efficient. All the public information is costless and available simultaneously to each participant in the market. The transaction cost for issuing stock is eliminated. Finally, the share price on the market is assumed to be reflecting the firm's expected future value, subject to the available information that the market possess.

Many researchers have done academic researches to test the validity of pecking order theory. Shyam-Sunder and Myers (1999), using a sample of 157 firms from year 1971 to 1989, find strong support to pecking order theory. They demonstrate that pecking order theory is better in explaining the investment behaviour of corporations. The result is also robust when tested with target adjustment model (the other model that is used to compare with pecking order theory). Additionally, they find that firms plan to cover the deficit by debt instead of stock, which is also in line with pecking order theory. López-Gracia and Sogorb-Mira (2008) find support for pecking order theory in Small and Medium-sized Enterprises (SMEs). They use data of 3,569 Spanish SMEs over 10 years and try to compare two models which are pecking order and tradeoff theory. The results reflect clear evidence in favour of pecking order theory. Similarly, Zoppa and McMahon (n.d.), who studied Australian SMEs, find supportive evidence for pecking order theory. The sample contains data from 871 Australian SMEs over the period from 1995 to 1998. They also suggest further development of pecking order theory which could reflect more financing behaviour of SMEs. The suggested pecking order theory is organized as follows:

- Reinvestment of profits
- Short-term debt (maybe personal credit card financing).
- Long-term debt (maybe from families and friends).
- New equity capital injections from existing owners and owner-managers (maybe families and friends, with zero or low dividend).
- New equity capital from hitherto uninvolved parties (maybe new owners and owner-managers, venture capitalists, business angels and Second Board listing).

There are researches give reverse opinions against pecking order theory as well. Franka and Goyal (2003) claim pecking order theory is not robust for their test. They tested the theory on publicly traded American companies over the period from 1971 to 1998. They find that internal fund is not sufficient to finance the investment and thus external funds are more widely employed. Among the external funds, debt is not found dominate to shares. Pecking order theory does not explain the sample well. They give a possible reason for the failure of pecking order by stating that more small firms, whose behaviour cannot be explained by pecking order theory, have gone for public trading. It lowers the average explaining power of pecking order theory. Using sample from Chinese listed companies, Ni and Yu (2008) claim no evidence is found to follow pecking order. Additionally, they found no evidence that firms with moderate debt level will follow pecking order theory (which is one of the findings in Myers 1984). It might because of the obstacle to enter Chinese bond market. There are strict criterions to follow if a company desires loan from the four state-owned commercial banks. Another reason could be due to the incompletion of Chinese legal system. Companies may prefer issuing shares without considering minority shareholders' rights properly, which not protected appropriately by law.

2.2 Financial Constraints

In Miller and Modigliani's world, there is no financial constraint. As the market is supposed to be well-functioning, firms' ability of raising funds is unlimited. The only concern for investment is the price at which a company can obtain funds. Even companies are short of internal funds, the gap can be easily offset by external capital because the outside investors keep seeking for such opportunities to make profit (Bond and Meghir 1994). However, the research into market behaviour suggested that internal funds are cheaper than external capital, due to information asymmetry and incentive problems. These constrain firm's financial behaviour.

Fazzari *et al* (1988) emphasized the effect of asymmetric information on raising external finance. For issuing new shares, as external investors cannot obtain the information that is kept inside the company, the cost of using that fund is higher. The managers are assumed to have better information about the quality of the assets and return of the investment. New shareholders, who cannot distinguish firms by quality due to information asymmetry and thus value firms as population average, do not know exactly how the investment will perform. Therefore, to compensate the potential lose on financing "lemons" (Akerlof 1970), they would expect higher return from investing in good companies. In this case, the managers of good companies may suffer from higher issuing cost of new shares, which may excess "the opportunity cost of internal finance faced by existing shareholders (Fazzari, Hubbard and Petersen 1988, p. 150)". The argument for issuing new debt is similar to the above discussion. Asymmetric information can also cause the interest rate to rise and force good borrowers leave the market. In summary, internal funds have cost advantage over external funds. In addition, in his co-authored paper with Athey, Fazzari presented that finance market might suffer from information asymmetry (Fazzari and Athey 1987) as well. Companies usually show the bright side of the investment to their lenders. Any information that is from the dark side is kept secret. Also, firms are not willing to release any information that may harm their competitive advantage, for example new technology.

Information asymmetry can lead to credit rationing as well (Stiglitz and Weiss 1981, cited in Fazzari and Athey 1987). Credit rationing happens when the lender supply smaller size of loan than the demand, even if the lender has enough fund (Jaffee and Russell 1976). Information asymmetry has two effects on lenders, which are adverse selection effect and incentive effect. As the lender does not have the full information about the borrowers' ability of repayment, they set up a "screening device" which is the interest rate. Those borrowers who are willing to pay a high interest rate are considered as riskier, because the probability of repayment for such borrowers is low (Stiglitz and Weiss 1981). In other words, the higher the interest rate, probably the lower the profit the lender can make from the loan, due to the higher default risk. As a result, there is an optimal interest rate for lenders beyond which the return for lending loans may decrease. Therefore, the lenders are not willing to raise interest rate even if there is excess demand for loan. In contrast, they control the total amount of loans issued, which lead to the phenomena that some borrowers can get the loan while others with same credit cannot (ibid). Credit rationing makes the use of external finance less favourable than internal funds.

Furthermore, agency cost also limits the use of external finance. Bernanke and Gertler (1989) demonstrated that agency cost could add premium to external finance, which makes external finance more expensive. Fazzari *et al* (1988) claimed that it could be created if a company employs large amount of debt. The managers may act in the interest of shareholders while ignore the rights of bondholders (moral hazard). Knowing this, bondholders will ask the company to provide some protection against such behaviour, for example covenant (Smith and Warner 1979), which may be costly and hence raise the cost of using debt.

Fazzari *et al* (1988) explained other factors that give cost advantage to internal funds, such as tax advantage and cost of financial distress. According to US tax system, the taxation for dividend is higher than that for retained earnings. Therefore, companies would rather maintain the earnings inside than paying out dividend to save taxation cost, which implies that internal capital is cheaper than external funds. When the company is not able to pay the interest for debt, financial distress problem occurs (see research by Opler 1993). The threat of financial distress raises the cost of debt, because investors of external finance will need a premium to compensate for the risk of company going bankruptcy.

2.3 Measurement of Financial Constraints

From the debate between Fazzari *et al* (1988) and Kaplan and Zingales (1997), it is clear that the choice of measurement of financial constraints can lead to diverse results. Moyen (2004) confirms this view in the research. She develops two models to identify firms with and without constraints, which is called constrained and unconstrained model. For unconstrained firms, she claims that dividend payment, investment, new debt issue and the interest rate for debt are the four factors a company needs to consider. The unconstrained model can be interpreted as "firm invests up to the point where the cost of one unit of capital equals next period's expected discounted marginal contribution to dividends (Moyen 2004, p. 2067)". Also, the model requires firms to balance between investment and interest rate, as high interest rate will attract more debt and hence benefit the company from tax shield effect but at the same time, raise the default risk from equity holders. To make the balance, the tax benefit of using one unit of debt, if equity holders do not default, should be equal to the default cost of the unit of debt if equity holders choose to do so. For constrained firms, Moyen allows the firm to have a constant debt obligation. As she explains, a firm may have accessed to external finance in the past, but later it was constrained. The debt obligation is left and should be taken into consideration. The constrained model limits firms' investment to the point that the shadow cost of one unit of capital equals to the expected discounted marginal contribution to dividend of next period, if the equity holders do not default. For both of the models, equity holder may choose to default when income shock is much smaller than expected and the future discounted value is not large enough to cover the interest payment.

In order to study the influence of measurement of financial constraints, she sets up five criterions. A firms is considered as constrained if it pays low dividend, or if it has low cash flow, or if it is predicted by the constrained model as constrained, or if it is described as constrained by the constrained model and has run out of internal funds, or if it has low Cleary's Index Value (as defined in Cleary 1999). She divided the 2000 firms in the simulated sample by those five criterions and run the regression model which is developed as in Fazzari *et al* (1988). Results show that constrained firms reveal lower investment-cash flow sensitivity (Kaplan and Zingales's results), if firms are divided by constrained model criterion and by Cleary's Index criterion. By contrast, Firms, identified by the other three criterions as constrained, show higher sensitivity (Fazzari *et al*'s results).

Moyen (2004) gives possible explanations for this. To understand Kaplan and Zingales's results, theoretically, higher cash flow leads to higher investment. However, constrained firms identified by constrained model have to choose from paying dividend or investment, which weakens the link between cash flow and investment. On the other hand, unconstrained firms borrow from external source to finance the investment, where the regression model does not control the effect of such capital. It magnifies the investment-cash flow sensitivity for unconstrained firms. By contrast, Fazzari *et al*'s results appear because unconstrained firms identified by unconstrained models are more likely to have heavier burden of interest payment, which indicates higher debt-to-equity ratio. Instead of not being able to pay dividend, these firms do not have to pay much dividend as they have less equity in the capital structure, although they appear to be low-dividend firms. These firms always bear higher sensitive on investment policies.

Almeida, Campello and Weisbach (2004) make some similar discussion on financial constraints. However, instead of studying investment-cash flow sensitivity, their research is focused on cash flow sensitivity of cash, which they define the term as "financial constraints should be related to a firm's propensity to save cash out of cash inflows (Almeida, Campello and Weisbach 2004, p. 1778)". If the cash flow sensitivity of cash is high, then the firm is considered as constrained. They created five criterions for classifying firms, which are firm payout policy, asset size, bond ratings, commercial paper ratings, KZ index as in Kaplan and Zingales (1997). Using data from publicly traded manufacturing firms, they find that the former four criterions apply that constrained firms appear to be highly sensitive to cash flow. The only exception comes from KZ index. Furthermore, they find that for constrained firms, the cash-cash flow sensitivity is negatively correlated with macroeconomic change, for example a recession, which means constrained firms save more during recession. This is true for the first four criterions but KZ index.

Unlike the previous papers, Almeida and Campello (2002) provided a different measure of financial constraints. They measure the constraints by quantity instead of quality. In the paper, they try to illustrate the effect of credit rationing on investment-cash flow sensitivity, as “it is the availability of credit, not the price which they [firms] have to pay, which limits their investment” (Greenwald, Stiglitz, and Weiss 1984, p.194, cited in Almeida and Campello 2002). According to their definition of constraint, they come up with different results as Fazzari *et al* (1988). The investment-cash flow sensitivity is found to decrease with financial constraints. Additionally, their find the relationship is not monotonic. They explain that under Fazzari *et al*’s and Kaplan and Zingales’ assumption, firms can use the external source as much as they can afford. Firms face the trade off between marginal cost of external finance and marginal productivity of investment. However, the interpretation of such functions is always ambiguous. Almeida and Campello’s model sets all constrained firms at similar level of marginal cost of external finance and hence avoid that problem. Furthermore, Almeida and Campello’s model has direct control over the ability of raising funds which makes it possible to capture the “multiplier” effect.

Schiantarelli (1996) discussed several problems in measurement of financial constraints. Firstly, some studies fix the firms’ financial status through the entire sample period. However, firms could possibly switch side during the sample period. For instance, one can be constrained in the past but no longer so in the later years. In the research, firms should be allowed to transfer between the two statuses. Secondly, the criterion used to separate samples into different groups may be endogenous. When firms are divided by dividend payment or firm size, endogenous problem is particularly true, because investment decision and dividend or firm size are inter-correlated. Schiantarelli suggests using lagged instrumental variable (IV) and GMM procedure to solve such problem. Additionally, one can also employ dummy variable in the regression model to interact the coefficient of cash flow variable. Thirdly, Schiantarelli claims that it is not necessary to divide firms based on predetermined criterions, aiming to obtain consistent estimator. This may lead to the error discussed in the first point. Firms may be misclassified using predetermined information. Finally, it may be not sufficient to separate firms by only one characteristic, which is especially true when one uses time dummy to capture the macro-environment conditions. It is suggested to use endogenous witching regression method to address this issue. By doing so, firms are not split by clear criterions, but assigned to functions of firms' characteristics, depending on which firms can be considered as either of the two conditions (like the constrained and unconstrained model developed by Moyen 2004).

Beyond the problems, Schiantarelli (1996) also states several ways of sample split. Despite the most commonly used method, such as dividend payout and firm size, he added business group, agency problem and concentration of ownership, and variation over time in the tightness of financial constraints. The criterion of business group has been used in Hoshi, Kashyap and Scharfstein (1991) who studied Japanese firms and found strong support to Fazzari *et al.* Agency problem is minimised if monitoring is efficient. The criterion is employed in Oliner and Rudebusch (1992) who found structure of share holding does not affect the investment-cash flow sensitivity. In the information-based models of investment, financial constraints are expected to vary according to the change of macro-environment and monetary policy. During a recession or after tightening monetary policy, fewer firms are expected to seek external finance, whose cost is too high. Using endogenous switching regression approach, Hu and Schiantarelli (1994) found that macro-environment conditions have significant effect on firms' financial status. Furthermore, the financial status of firms can be affect by the change in the structure of financial market. During the 1980s, many developing countries have been trying to remove the restrictions on inner financial markets, leading to lower entry barriers for banking sector and stimulated the development of security market, which brings in more funds for investment. In addition, banks became trusted source of external finance and were believed to dominate informal financial markets. These all contribute to reducing the cost of external finance. Meanwhile, subsidized credit programmes were withdrawn and hence those firms who benefited from such programmes before may become financially constrained. Harris (1994), who studied Indonesia financial market, provided evidence of this. He found that the investment-cash flow sensitivity for smaller firms are less fierce after financial liberalization.

2.4 Investment Models

2.4.1 Neoclassical Model

Although the assumption of MM theory is not satisfied in real life, it proves a basis for many other researches and theories. Hall and Jorgenson (1967) developed neoclassical model of investment on the foundation of MM's work in their paper of studying the relationship between tax policy and investment behaviour. They explained the neoclassical theory of optimal capital accumulation in two ways, both of which are equivalent. One is that firms accumulate assets to supply their own investments, where the purpose is to maximize the company's value. The other is that firms rent assets from themselves or other firms, where the purpose is to maximize current profit. The regression model that reflects the relationship between tax policy and investment behaviour is derived from the second explanation. Although the relationship is not the interest of this paper, the investment model should be discussed here. Their study concludes that the investment of a period equals to replacement investment of the capital stock at the beginning of the period plus any change in the desired level of capital stock in the past periods. The model is given as below:

$$I_t = \sum_{s=0}^{\infty} \mu_s \Delta K_{t-s}^{+} + \delta K_t.$$

where I_t stands for the gross investment of period t, K is the capital stock, ΔK^+ is the change in desired capital stock, μ_s is an parameter indicating the change in desired capital stock for period (t-s), δ stands for a constant proportion (depreciation).

The outcome is based on several important assumptions. Firstly, the objective of firms is to maximize their profit and the market is set to be perfect, for example, there is neither information cost nor taxation. Secondly, following a change in the desired level of assets, a certain percentage of subsequent investment is expended over each period. In addition, as a result of investment, a proportion of capital is replaced over each period. The scale of the proportion depends on different class of assets and is irrelevant to calendar time (Hall and Jorgenson 1967).

Both MM theory and the finds of Hall and Jorgenson believe that company's capital structure is irrelevant to investment decisions. The source of finance does not influence investment decisions. The research following neoclassical investment model during that period seems to dominate liquidity theory or internal funds theory, although there are some other researchers studying internal funds (for example Donaldson (1961) claimed that management generally favoured internal source of finance except for some occasions when fund was badly needed.) A noticeable paper of this is the one carried out by Jorgenson and Siebert (1968). The paper compared four different investment models which are neoclassical, accelerator, expected profits and liquidity. Jorgenson and Siebert (1968) claimed that they had selected best lag distribution to keep the research unbiased from "misspecification of the lags structure or from inappropriate assumptions about homogeneity of investment behaviour across firms (Jorgenson and Sirbert 1968, p. 708)". They found that the neoclassical theory, which gives better explanation of investment behaviour, is superior to other theories.

However, Elliott (1973) showed opposite opinion against Jorgenson and Siebert. Following the study of Jorgenson and Siebert (1968), he tried to compare four investment models as well. He extended the sample size used in the research, enlarging to 184 firms which were selected from a variety of industries, instead of only 15 in Jorgenson and Siebert (1968). Elliott found that there was only small difference in the importance of neoclassical, accelerator, and liquidity model. The expected profits model is relatively unimportant compared with the other three. In addition, liquidity theory is found to be the most effective model while neoclassical theory is the least effective one, which was conflict to Jorgenson and Siebert.

2.4.2 Tobin's Q Model

In recent years, a new model that reflects the relationship of investment and internal funds has become the focus of financial researches, which is developed from Tobin's Q model. Fazzari, Hubbard and Petersen (1988) firstly carried out the model in their research paper, which has been cited widely by the following studies. They believe that internal funds and external funds are not perfect substitutes. Otherwise, firm's capital structure would not affect investment decisions. The model is developed as follows:

$$(I/K)_{it} = f(X/K)_{it} + g(CF/K)_{it} + u_{it},$$

where I stands for the investment in assets of firm *i* at period t. X represent some variables that are used to control determinants of the investment. g is a function of cash flow (CF) which is used to measure the sensitivity of internal funds to investment. u is the error term. Fazzari *et al* employed Tobin's Q which is usually used to control the investment opportunities to represent determinants of the investment (X in the regression model). Tobin's Q was named after James Tobin who was an American economist and was originally discussed in Brainard and Tobin (1968). All variables are divided by K which is the capital stock at the beginning of each period.

To carry out the research, the measure of financial constraints must be considered. Fazzari *et al* chose retention rate to distinguish firms. According to the theoretical base that internal funds should be employed first, they argue that if a firm is financially constrained, it should choose to cut back dividend or rather not pay any dividend at all. Hence, high retention ratio (which means low dividend payment) reflects that firms are constrained. The more a company is constrained, the more significant influence cash flow (the indicator for internal funds) should have on the investment and the scale should be greater than less constrained ones. If the hypothesis stands, investment is more sensitive to cash flow for financially constrained firms. Using data from manufacturing industry, Fazzari *et al* proved their argument and found that cash flow had a strong positive effect on investment, which implied that internal capital did significantly affect the investment decision. In addition, the coefficient for firms with low dividend payment was higher than that for high dividend firms, which meant constrained firms are more sensitive to internal funds than unconstrained ones.

The findings of Fazzari *et al*'s work is widely accepted and followed by other researchers. Hoshi, Kashyap and Scharfstein (1991) gave strong support to Fazzari *et al*. They took Japanese firms as research target and divided the sample into two groups, one of which maintained a close relationship with banks and the other did not. The firms that had tight relationship with banks usually belong to a keiretsu. These firms were considered to be financially unconstrained and those independent ones were thus constrained. Hoshi *et al* found that keiretsu firms were less sensitive to internal funds than that of independent ones.

However, their findings are challenged by Kaplan and Zingales (1997). The financial constraints used in Kaplan and Zingales' research are different. Instead of retention ratio, they try to record the investment-cash flow sensitivity of firms by reading the annual reports and managements' prospect about the future liquidity. Such information is integrated with quantitative data and public news to predict the availability of internal and external funds, as well as the future need for capital. Based on these researches, Kaplan and Zingales distinguish firms between constrained and unconstrained. The different definition of financial constraints gives completely opposite results against the findings of Fazzari *et al* (1988). Kaplan and Zingales conclude that less constrained firms are likely to experience higher investment-cash flow sensitivity. Furthermore, they find that the relationship is non-monotonic. Therefore, they show strong disagreement to the findings of Fazzari *et al* (1988).

A similar approach is taken by Hovakimian (2009). He has accessed to firm-level information on the sensitivity of investment on cash flow, based on which he classify firms into high, low and negative sensitive groups of cash flow. For each of the group, he analyzes the possible factors that may determine the fierceness of financial constraints, including liquidity, growth rate, and investment and financial behaviour. Interestingly, although Hovakimian uses similar method as in Kaplan and Zingales, the findings seems to partially support Fazzari *et al* (1988). He finds that firms with positive investment-cash flow sensitivity face higher cost of external finance, which means greater financial constraints. A possible explanation could be that these firms are typically young and small, which makes them difficult to borrow loan from external resource. Additionally, these firms are more fragile on liquidity problem. The spending on investment may exceed the capacity for internal funds and hence the desire for external source is greater than those who are insensitive.

The findings in Hovakimian (2009) are close to an earlier work which is completed by Alti (2003). The author analyzes investment-cash flow sensitivity in the benchmark case where financing is frictionless and concludes that young and small firms with high growth rate and low dividend payment are relatively higher in investment-cash flow sensitivity. Instead of using Tobin's Q model, Alti develops an investment model "based on the standard neoclassical models of Lucas (1967), Treadway (1969), and Hayashi (1982) (Alti 2003, p. 708)". He believes that Tobin's Q is noisy in measuring short-term investment of firms (see the discussion below).

2.5 Other Works Based on Tobin's Q Model

Vogt (1994) studied the reason why cash flow is important to investment decision by employing Q model. He proposes two hypothesises which are free cash flow hypothesis and pecking order hypothesis. If free cash flow hypothesis is able to explain investment-cash flow sensitivity, firms with low Q value should rely on cash flow to finance investment. By contrast, if pecking order theory can explain the relationship, firms with high Q should rely on cash flow to finance investment. The logic is that firms with excess free cash flow would invest in unprofitable projects to increase the managers' wealth (agency problem as in Jensen 1986), which will lead to low Q value, whereas firms driven by pecking order theory would give up good investment opportunities to avoid additional cost of external finance, where a high Q value will appear. Using data from 359 manufacturing firms over 1974 to 1990, he finds that "large, low-dividend firms exhibit free cash flow behaviour, while small, low-dividend firms exhibit pecking order behaviour (Vogt 1994, p. 18)".

Fazzari and Petersen (1993) tested the role of working capital in the reduced-form investment model. They claimed that cash flow might only indicate the demand for investment instead of a proxy for financial constraints. By contrast, working capital could avoid the confusion. If a firm was constrained, working capital and investment would compete against each other for scarce source. Hence working capital should have a negative coefficient in the conventional investment model, indicating any increasing in working capital would lead to decline in investment. The empirical results supported this prediction and showed that working capital was extremely sensitive to cash flow.

There are many other empirical researches studying investment-cash flow sensitivity. Galeotti and Schiantarelli (1991) have developed a more general Q model for monopoly firms, which allowed for adjustment for labour cost. Blundell *et* *al* (1992) dropped cash flow from the conventional investment model and employed Q as the single explanation variable. They found that although the effect of Q is small on investment, the influence is significant. Kadapakkam, Kumar and Riddick (1998) shed light on the effect of firm size on investment-cash flow sensitivity. They test data from six OECD countries and find that generally, the sensitivity is high in large size firm group but low in small size firm group. Lorenzoni and Walentin (2007) emphasize the effect of insiders' information on Tobin's Q and draw the conclusion that Q reflects a future quasi-rent that is taken by insiders, and thus creates a wedge between average Q and marginal Q. For more researches, one could also see Lamont (1997), Ericson and Whited (2000), and Carpenter, Fazzari and Petersen (1998).

2.6 Discussion of Tobin's Q

Q theory of investment, which is described in detail in Brainard and Tobin (1968) and Tobin (1969), uses information from market to predict the future investment opportunity. In theory, marginal Q can be taken as one determinant for firm's investment. It measures the ratio of market value of an additional capital invested to the replacement cost (Hayashi 1982). If the ratio is greater than one, it will be beneficial for firms to make investment (Chirinko and Schaller 1995). However, as marginal Q is unobservable, empirical studies usually use average Q instead. It is defined as the market value of the firm to the replacement cost of its capital stock. Hayashi (1982) proved that marginal Q and average Q are equivalent "if the firm is a price-taker with constant returns to scale in both production and installation (Hayashi 1982, p. 214)". Additionally, Hayashi also illustrated that average Q could be higher than marginal Q if the firm is a price-maker.

A large number of researches have taken average Q as the measure of future investment opportunity. Chung and Pruitt (1994) present an approximate value of average Q which is:

$$Q = \frac{MVE + PS + DEBT}{TA}$$

where MVE means market value of equity which is equal to market share price multiplied by common shares outstanding, PS is the market value of preferred stock, DEBT is the value of short-term liability minus short-term assets plus long-term debt, and TA is the book value of total assets. However, this is believed not to be Q but a derivative of Q.

As the condition for average Q to be equal to marginal Q is strict, taking average Q as the indicator of future investment opportunity could be problematic (Gugler, Mueller, and Yurtoglu 2004). They claim the higher the average Q is, the cheaper it should be for firms to raise funds and hence the less sensitive cash flow is to investment. Meanwhile, average Q is also used in their research to predict agency problem that a firm may suffer from. Unlike other empirical studies, they employ marginal Q to control the investment opportunity and average Q is used to control the above factors. The process to derive marginal Q lays on assumption of efficient market. In addition, predictable industry depreciation rate and industry-specific time shock (to control random shock) are also required. The final formula is given as follows:

$$\overline{qm} = \frac{M_{t+n} - M_{t-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} \delta_{Dt+j} M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \sigma_{Dt+j} M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \mu_{t+j}}{\sum_{j=0}^{n} I_{t+j}}.$$

where qm stands for marginal Q, M is the market value of the firm, I represents the investment, δ is the industrial depreciation rate (on both tangible and intangible assets) and σ stands for the industry-specific time shock. Gugler *et al* (2004) state that when n is large enough, the last term is relatively too small to take into account and hence this formula provides an approximately measure of marginal Q.

Carpenter and Guariglia (2003) claim that in the presence of information asymmetry, Q will only reflect the outsiders' evaluation of the company, due to the information gap between insiders and outsiders. The investment-cash flow sensitivity may be caused by the insiders' evaluation of opportunity, which is not captured by Q. Therefore, they suggest to add a new proxy to capture the insiders' view about the future opportunity, which is named as "the firm's contractual obligations for future new investment projects (Carpenter and Guariglia 2003, p. 3)". It is the contract to purchase asset in the future, for example machinery, land, and equipment. The information is obtained from companies' annual report. According to the contract, the firm has to make the purchase in the agreed future time, which makes it a possible proxy for insiders' evaluation of opportunity. By studying UK panel data, Carpenter and Guariglia (2003) find that the sensitivity for large firms are reduced after employing the new proxy but it is not changed for small ones. A similar procedure is followed by Bond *et al* (2004). They add one more proxy which is used to control expected future profit, and draw the conclusion that the coefficient for cash flow variable become insignificant.

CHAPTER Ⅲ METHODOLOGY

Based on the review of previous literature, this study tries to answer the following questions:

(1) Does the availability of internal finance affect firms' investment behaviour?

(2) To what extent does internal finance affect investment levels of financially constrained and unconstrained firms?

(3) Will different measurement of financial constraints affect the outcome?

Test will be carried out based on four commonly used methods. Firstly, Ordinary Least Squares (OLS) estimator will be generated without considering time-specific and firm-specific effects. Secondly, fixed-effect (within) model and random-effects model will be used alternatively, taking time-specific and firm-specific influences into consideration. Furthermore, first-differencing transformation will be employed to transform the model to eliminate time-specific and firm–specific effects. Finally, instrumental variable with Generalized Method of Moments (GMM) will be employed to deal with endogenous problem. Results from each test will be compared.

3.1 The Model

To answer these questions, building a regression model is necessary. The standard empirical Q model assumes that firms choose to finance as much investment as they can, as long as they are able to pay the price of that finance. The only factor that will affect firms' decision is the investment opportunity (Brainard and Tobin 1968). The standard empirical Q model is formulated as:

$$\frac{I_t}{K_t} = a + \frac{1}{b} Q_t + \epsilon_t \qquad (1)$$

where I_t is the gross investment, K_t is the net capital stock, Q_t equals to (q_t.- 1) where q_t is marginal Q, ϵ_t is an error term or white noise, and a and b are structural parameters of adjustment cost function (Schiantarelli 1996). As marginal Q is unobservable, empirical studies usually use average Q instead, which is just the market value of fixed assets divided by book value of fixed assets or replacement capital. The replacement capital is the cost of fixed assets minus accumulated depreciation and amortization:

$$BV = (1 - \delta)c \tag{2}$$

where c is the cost of fixed assets and δ is the accumulated depreciation rate.

In this study, I will test average Q to capture the investment opportunity as Hayashi's conditions do not hold in real life. Average Q will be introduced into the investment model which is developed by Fazzari *et al* (1988):

$$\frac{I_{it}}{K_{it\text{-}1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it\text{-}1}} + \alpha_2\, Q_{it\text{-}1} + \varepsilon_{it} \tag{3}$$

where I_{it} stands for investment, CF_{it} (cash flow) is the indicator used to present internal finance, Q_{it} is the average Q, $K_{it\text{-}1}$ is the capital stock at the beginning of the period t, and ε_{it} is an error term.

To measure the variables in the above model, I will borrow the definition from Moyen (2004):

Investment at time *t*	=	capital spent on purchasing fixed assets at time *t*
	=	[total gross property, plant and equipment at time *t* – accumulated depreciation and amortization at time *t*] – [total gross property, plant and equipment at time (*t-1*) – accumulated

		depreciation and amortization at time (*t-1*)] + depreciation and amortization at time *t*
Capital stock at time *t*	=	total gross property, plant and equipment at time *t* - depreciation at time *t*
Market value	=	closing share price at end of fiscal year × common share outstanding + long-term debt
Book value of fixed assets	=	total gross property, plant and equipment – accumulated depreciation and amortization
Cash flow at time *t*	=	income before extraordinary item + depreciation and amortization + deferred tax

3.2 Solution to Question (1)

After building the model, I will try to answer the first research question by OLS method as a starting point. To generate Best Linear Unbiased Estimator (BLUE) from OLS, several assumptions must hold, which include multicollinearity, heteroscedasticity and serial correlation. Multicollinearity exists when there is strong linear relationship between independent variables. In the presence of multicollinearity, it is difficult to assess the individual impact of independent variables on dependent variable, in this study, cash flow on investment. Although the estimator is still BLUE, OLS estimators will have large variance. Additionally, the estimator may tend to be insignificant even if actually it is. There are several ways to detect the problem, such as extraordinary high R-squared value, high Variance Inflating Factor (VIF, if greater than 10) or low tolerance value (if smaller than 0.1). Secondly, heteroscedasticity should be tested. The problem is caused by inconstant error term which varies with independent variable. If heteroscedasticity exists, the estimator is linear, unbiased and consistent, but not efficient (Wooldridge 2008). The reported P-value should not be trusted. Scatter diagram between fitted value of independent variable and square of residuals can be used to detect heteroscedasticity. Alternatively, Breusch-Pagan test or White test is also suitable for this purpose. Finally, serial correlation occurs when the error term is not independent over time, for example, the error term of this period may be correlated with that of the last. The problem will lead to inefficient estimator and inappropriate p-value. In this study, I will use the method developed by Wooldridge (2002) to detect this error. All of these problems will affect the accuracy of the result, hence must be handled with care.

It is arguable from recent literature that using OLS is not appropriate, even if all the assumptions are binding. The simple regression model (3) does not concern firm-specific and time-specific effect, for example new technology or major economical environment change. Studies usually involve firm and time dummies to reflect such effects. In econometrics, the firm-specific effect is called firm heterogeneity. If the heterogeneity term is correlated with the independent variables, fixed-effect model, which is also called Least Squares Dummy Variables Model, is more efficient than random-effect model. OLS procedure will be sufficient to predict the coefficients for the variables. However, if the heterogeneity term is not correlated with the independent variables, one should use random-effect model and instead of OLS, GLS (Generalised Least Squares) is a better estimator. To decide which model to use, I follow Hausman test to choose between the models. The null hypothesis for Hausman test is that random-effect model is appropriate. From business common sense, I believe the heterogeneity term is correlated with the independent variables hence I expect the test to reject the null hypothesis and prefer fixed-effect model.

Another common way to withdraw heterogeneity term is to transform the model. By transforming, firm heterogeneity term and time dummy is dropped out of the model, which eliminates the potential influence of the two. There are several methods to do so, such as within transformation and first-differencing transformation, where first-differencing is essentially to deal with the dynamic nature of the investment model. In this research, I will transform the model by first-differencing. The model is developed as:

$$\frac{I_{it}}{K_{it-1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it-1}} + \alpha_2\, Q_{it-1} + \alpha_3 f_i + \varepsilon_{it} \tag{4}$$

where f_i is the firm heterogeneity term.

The logic of first-differencing is explained here. It requires lagging model (4) by one period, which becomes:

$$\frac{I_{it-1}}{K_{it-2}} = \alpha_0 + \alpha_1 \frac{CF_{it-1}}{K_{it-2}} + \alpha_2\, Q_{it-2} + \alpha_3 f_i + \varepsilon_{it-1} \tag{5}$$

Then subtract (5) from (4), the transformed model becomes:

$$\left(\frac{I_{it}}{K_{it-1}} - \frac{I_{it-1}}{K_{it-2}}\right) = \alpha_1 \left(\frac{CF_{it}}{K_{it-1}} - \frac{CF_{it-1}}{K_{it-2}}\right) + \alpha_2\big(Q_{it-1} - Q_{it-2}\big) + \ (\varepsilon_{it} - \varepsilon_{it-1}) \tag{6}$$

As the firm heterogeneity is same for each period, it is subtracted from model (6). Test will be carried out based on equation (6) to see the influence of cash flow on investment after controlling firm-specific effects. The results will be compared with the above OLS estimators. It is noticed that the error term is serially correlated. However, most econometric software packages can adjust this error.

Finally, instrumental variables are employed to test the influence of cash flow on investment. Several studies have found that lagged investment rate also significantly affect investment decisions (see Guiso and Parigi 1999, Ghosal and Loungani 2000). I hence add investment rate lagged one period into equation (5) and derive:

$$\frac{I_{it}}{K_{it\text{-}1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it\text{-}1}} + \alpha_2\, Q_{it\text{-}1} + \alpha_3 f_i + \alpha_4 \frac{I_{it\text{-}1}}{K_{it\text{-}2}} + \varepsilon_{it} \tag{7}$$

Equation (7) is a dynamic model. Similar to the derivation of equation (6), the firm heterogeneity term can be eliminated by first-differencing transformation. The transformed model is:

$$\left(\frac{I_{it}}{K_{it\text{-}1}} - \frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right) = \alpha_1 \left(\frac{CF_{it}}{K_{it\text{-}1}} - \frac{CF_{it\text{-}1}}{K_{it\text{-}2}}\right) + \alpha_2\left(Q_{it\text{-}1} - Q_{it\text{-}2}\right) + \alpha_4 \left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}} - \frac{I_{it\text{-}2}}{K_{it\text{-}3}}\right) + (\varepsilon_{it} - \varepsilon_{it\text{-}1}) \tag{8}$$

or:

$$\Delta\left(\frac{I_{it}}{K_{it\text{-}1}}\right) = \alpha_1 \Delta\left(\frac{CF_{it}}{K_{it\text{-}1}}\right) + \alpha_2 \Delta Q_{it\text{-}1} + \alpha_4 \Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right) + \Delta\varepsilon_{it} \tag{9}$$

Although firm heterogeneity term is eliminated, there is new problem with equation (8) and (9). $\Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right)$ and $\Delta\varepsilon_{it}$ is now correlated, which in other words, there is endogenous problem. To prove this, as $\Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right) = \frac{I_{it\text{-}1}}{K_{it\text{-}2}} - \frac{I_{it\text{-}2}}{K_{it\text{-}3}}$, $\Delta\varepsilon_{it} = \left(\varepsilon_{it} - \varepsilon_{it\text{-}1}\right)$, and from equation (5), it is clear that $\Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}1}}\right)$ and $\Delta\varepsilon_{it}$ both contain $\varepsilon_{it\text{-}1}$, thus they must be correlated.

When endogenous problem occurs, OLS is not suitable because the estimator will be biased and inconsistent. An alternative method is to use instrumental variables

(IV). By employing IV, endogeneity bias is controlled for by instrumenting the regressors (Arellano and Bond 1991). As the model is dynamic, I choose investment rate lagged two and three periods to be IV, which is $\frac{I_{it\text{-}2}}{K_{it\text{-}3}}$ and $\frac{I_{it\text{-}3}}{K_{it\text{-}4}}$. It will be first-differenced and run by GMM. The model to be tested is equation (7). The estimator $\alpha_1, \alpha_2, \alpha_4$ should be BLUE. The results will be compared with that from OLS, fixed-effect model and first-differencing transformation.

There are three important tests for the validity of IV. Firstly, the instrumental variable should not be part of the regression model. Neither $\frac{I_{it\text{-}2}}{K_{it\text{-}3}}$ nor $\frac{I_{it\text{-}3}}{K_{it\text{-}4}}$ is included in equation (7), which satisfies the requirement. Secondly, the instrumental variable should be correlated with the endogenous variable. If not, the instruments are called weak instruments and will bias the IV estimator. In this case, $\Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right)$ is clearly correlated with $\frac{I_{it\text{-}2}}{K_{it\text{-}3}}$. It is easy to prove that $\Delta\left(\frac{I_{it\text{-}1}}{K_{it\text{-}2}}\right)$ is correlated with $\frac{I_{it\text{-}3}}{K_{it\text{-}4}}$ as well. Lastly, instrumental variable should not be correlated with error term. Neither $\frac{I_{it\text{-}2}}{K_{it\text{-}3}}$ nor $\frac{I_{it\text{-}3}}{K_{it\text{-}4}}$ is correlated with $\Delta\varepsilon_{it}$. As $\frac{I_{it\text{-}2}}{K_{it\text{-}3}} = \alpha_0 + \alpha_1 \frac{CF_{it\text{-}2}}{K_{it\text{-}3}} + \alpha_2 Q_{it\text{-}2} + \alpha_3 f_i + \alpha_4 \frac{I_{it\text{-}3}}{K_{it\text{-}4}} + \varepsilon_{it\text{-}2}$, whereas $\Delta\varepsilon_{it} = \left(\varepsilon_{it} - \varepsilon_{it\text{-}1}\right)$. They have nothing in common. The same applies to $\frac{I_{it\text{-}3}}{K_{it\text{-}4}}$.

In empirical studies, Hansen's J-test is usually used to test the instruments exogeneity. It is also called the test for overidentifying restrictions with a null hypothesis that all instruments are valid. The test statistics will have a chi-squared distribution with degrees of freedom equal to the number of surplus instruments. In this research, the J-test should have one degree of freedom.

3.3 Solution to Question (2) and (3)

After discussing the general effect of cash flow on investment, I will move forward to study the difference between financial constrained and unconstrained firms. There are many indicators been used to split the sample into constrained and unconstrained groups. I will firstly test the most popular ones which are dividend payment and firm size. Then I will interact the two criterions together, as Schiantarelli (1996) claimed that using one criterion to group companies might not be sufficient.

To analyze cash flow effect on investment by classifying firms by dividend payment, I will add a slope dummy variable in equation (7) to interact with cash flow:

$$\frac{I_{it}}{K_{it\text{-}1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it\text{-}1}} + \alpha_2\, Q_{it\text{-}1} + \alpha_3 f_i + \alpha_4 \frac{I_{it\text{-}1}}{K_{it\text{-}2}} + \alpha_5 [D_{div} \times \left(\frac{CF_{it}}{K_{it\text{-}1}}\right)] + \varepsilon_{it} \qquad (10)$$

where D_{div} is the dummy variable for dividend. Dividend payment is divided by capital stock at the beginning of each period for deflating purpose, named dividend rate. D_{div} is defined as 1 if the dividend rate is higher than average, while 0 otherwise. In other words, following the argument from Fazzari *et al* (1988), unconstrained firms are the ones who pay higher dividend and hence labelled 1. By contrast, constrained firms are the ones labelled 0. From equation (10), it is clear that cash flow effect on investment for unconstrained firms is $(\alpha_1 + \alpha_5)$ whereas constrained firms is just α_1. If Fazzari *et al*'s theory is valid, I expect α_5 to be negative and statistically significant.

After discussing dividend payment criterion, I will split the sample by firm size. There are several figures popular to define firm size. I will borrow the determinants from Kadapakkam, Kumar and Riddick (1998). They used market value of equity, total assets, and sales as indicators for firm size. For simplicity, I will use total assets and sales to separate firms only. Similar to the analysis for dividend criterion, I divide the two by capital stock at beginning of each period and name them total assets rate and sales rate respectively. Dummy variables are created to present the effect of firm size. The dummy variable is also interacted with cash flow:

$$\frac{I_{it}}{K_{it\text{-}1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it\text{-}1}} + \alpha_2\, Q_{it\text{-}1} + \alpha_3 f_i + \alpha_4 \frac{I_{it\text{-}1}}{K_{it\text{-}2}} + \alpha_5 [D_{ta} \times \left(\frac{CF_{it}}{K_{it\text{-}1}}\right)] + \varepsilon_{it} \qquad (11)$$

where D_{ta} is the dummy variable for total assets, which in the subsequent analysis will be replaced by D_{ts}, the dummy variable created for sales. Both of the dummy variables are given the value 1 if the subject they stand for is higher than average. It is commonly believed that small firms are relatively more constrained to external finance, which means small firms are more sensitive. Hence I would expect the coefficient for α_5 to be negative and statistically significant, regardless whether firm size is measured by total assets or sales.

Following the test of firm size criterion, I will interact dividend with firm size to test the investment-cash flow sensitivity. The dividend dummy will be multiplied by firm size dummy. The meaning for different combination is presented in the following matrix (Table 3.1). All the dummy variables are as defined above.

Table 3.1 Matrix for Dividend and Firm Size Dummy

		Dividend Dummy	
		0	1
Firm Size Dummy	0	Small firms paying low dividend	Small firms paying high dividend
	1	Large firms paying low dividend	Large firms paying high dividend

Equation (12) will be tested to reveal the interactive effect of dividend and firm size. In theory, small firms paying low dividend should be the most constrained firms. By contrast, large firms paying high dividend are considered to be most unconstrained. Therefore, small firms paying low dividend is expected to be most sensitive and large firms paying high dividend should be least sensitive. The other two combinations may lie in the middle.

$$\frac{I_{it}}{K_{it\text{-}1}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it\text{-}1}} + \alpha_2\, Q_{it\text{-}1} + \alpha_3 f_i + \alpha_4 \frac{I_{it\text{-}1}}{K_{it\text{-}2}} + \alpha_5 \left[D_{div} \times \left(\frac{CF_{it}}{K_{it\text{-}1}}\right)\right] + \alpha_6 \left[D_{ta} \times \left(\frac{CF_{it}}{K_{it\text{-}1}}\right)\right] + \alpha_7 \left[D_{div} \times D_{ta} \times \left(\frac{CF_{it}}{K_{it\text{-}1}}\right)\right] + \varepsilon_{it} \qquad (12)$$

All the above equations, (10) (11) and (12), will be carried out by GMM with instrumental variable of $\frac{I_{it}}{K_{it\text{-}1}}$ lagged two and three periods. Schiantarelli (1996) claimed that investment and dividend or firm size could be endogenous, for which instrumental variables should be utilized. In addition, for comparison, I will also employ fixed-effect model to test equation (4) after adding in each dummy variable separately as well as the interactive dummy. The reason of not choose first-differencing transformation is that all variables will be first differenced in GMM. Hence, these two methods may reveal similar outcome. The results for each splitting criterion will be compared.

Finally, Moyen (2004) suggests interpreting mean and correlation between variables to explain the difference between constrained and unconstrained firms. She conducts correlation matrix for constrained and unconstrained firms separately. I will follow the same pattern to generate correlation matrix for the selected sample. I expect the findings from this to support the outcome from the above analysis.

CHAPTER Ⅳ DATA AND ANALYSIS

4.1 Data Collection and Description

Panel data is believed to be suitable for the study. Hsiao (2006) concludes several advantages of panel data. As panel data contains more degree of freedom and variables, it can generate estimators which are more accurate. In addition, panel data has better control over omitted variables, which may significantly influence the outcome. In studies of dynamic models, panel data allows researchers to reduce collinearity between current and lagged values. Furthermore, panel data is helpful to simplify the computation and statistical inference in some cases, for example, reducing measurement error by transforming.

Following Moyen (2004) and Cleary (1999), I take the sample data from manufacturing industry with Standard Industry Code (SIC) from 2000 to 3999. Data is retrieved from COMPUSTAT North America database. The sample period is set to be the most recent 10 years which is from 1999 to 2008. I choose the firms reporting financial statements on consolidated level with US dollar as the reporting currency. Besides, firms have to be active through the whole sample period. Firms from financial service side are excluded from the sample due to the complexity of their financial statements. Originally, there are 2,763 firms forming 26,180 firm-year observations. Unfortunately, not every company has full information through the 10 years. In order to make the research as accurate as possible, I delete all the firms who do not report total assets, investments, or cash flow, as well as those with a large amount of missing values. The sample size is finally reduced to 2,233 companies with 20,511 firm-year observations. The sample is unbalanced with the observed years varying for each company from 4 to 10 years. Table 4.1

reports the descriptive data of the main items used in the research.

Table 4.1 Descriptive Data of Raw Material

Variable	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*
CAPX	20,511	149.9754	1,036.18	-.105	40,595.29
IBC	20,511	139.6217	1,136.959	-24,474	45,220
DPC	20,511	126.9381	768.7119	0	44,667
TXDC	20,511	-0.5187	115.5974	-5,477	4,283
CSHO	20,511	117.9997	492.2261	.001	23,177.63
PRCC_F	20,511	15.57192	25.68142	.0001	983.02
DLTT	20,511	515.6103	3,565.487	0	191,133
PPENT	20,511	801.2666	4,976.061	0	121,346
DV	20,511	56.94581	379.1149	-.042	10,342
AT	20,511	2,762.345	14,399.66	0	448,507
SALE	20,511	2,436.452	13,041.14	-.234	425,071

From the data manual provided by COMPUSTAT, capital expenditure is defined as the capital invested in acquiring additional fixed assets (property, plant and equipment), which in this research is employed as investment (I_{it}). I create *cashflow* to capture cash flows of firms, which is the sum of *IBC*, *DPC* and *TXDC*. The market value of average Q is derived as *CSHO* multiplied by *PRCC_F* and then plus long-term debt (*DLTT*). All items are divided by K_{t-1} which is the capital stock at the beginning of the period to generate the variables in equation (3). The descriptive data of these variables are summarized in Table 4.2. Due to some missing values left in the above items, the observations are reduced to 16,921.

It is clear that some statistics are out of normal range, for example, negative investment rate. I believe this is caused by extreme values or outliers effect. Therefore, I process the extreme values or outliers for relevant variables by winsorizing the data. I follow the process in Moyen (2004) and Cleary (1999):

Tobin's Q between 0 and 10, *INV* between 0 and 2, *CF* between -5 and 5. One advantage of winsorizing is that it keeps observations in the sample, as well as information about high and low errors (Armstrong and Collopy 1992, Stoltzfus and Epps 2005). Winsorizing is widely used in panel data research to control the effect of outliers (see Bond *et al* 2003, Cummins *et al* 1999). I report the winsorized statistics in Table 4.3 below. In the following research, winsorized dataset is used instead of the original data. The winsorized dataset is better compared with that in Table 4.2 without reducing the number of observations.

Table 4.2 Descriptive Data of Variables

Variable	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*
INV	16,921	.9576248	30.09751	-.2644836	2924
CF	16,921	-15.82232	213.6293	-12231.5	11913
Q	16,921	162.9293	2327.544	.000934	226660

where *INV* = $\frac{I_{it}}{K_{it-1}}$, *CF* = $\frac{CF_{it}}{K_{it-1}}$, *Q* is the average q at the beginning of the period.

Table 4.3 Winsorized Data of Variables.

Variable	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*
INV	20,511	.6218846	.7380411	0	2
CF	20,511	.425159	3.0531	-5	5
Q	20,511	7.478116	3.373605	.000934	10

where *INV* = $\frac{I_{it}}{K_{it-1}}$, *CF* = $\frac{CF_{it}}{K_{it-1}}$, *Q* is the average q at the beginning of the period.

4.2 Data Analysis

4.2.1 Answer to Question (1)

As a starting point, I run equation (3) without considering time-specific and firm-specific effects. The regression model gives the following relationship between investment and cash flow, reported in Table 4.4. Cash flow has positive effect on investment rate (0.121), indicating higher cash flow leads to higher investment rate, or increase in internal capital will encourage firms to invest more in fixed assets, *ceteris paribus*. The figure is considered to be significant at 5% significance level (with p-value less than 0.1). Q is found to be positively and significantly affect investment as well (0.088) with a p-value less than 0.1. The goodness-of-fit for the model is also reasonable, with an R-squared of 0.4651.

Table 4.4 OLS Results

	Coef.	Std. err	P-value	Std. err robust	P-value
CF	.1214746	.0012449	0.000	.0015914	0.000
Q	.0877112	.0011267	0.000	.0008871	0.000
_cons	-.0856756	.009183	0.000	.0043605	0.000

It is essential to test the assumptions for OLS in order to generate BLUE estimators. I test multicollinearity and heteroscedasticity respectively. I found no evidence for multicollinearity (VIF less than 10 and no correlation of variables higher than 0.75). However, heteroscedasticity is found to present (p-value of White test well below 0.01 level). When heteroscedasticity problem is presented, the estimation is not efficient which gives wrong standard error, although the coefficients are still linear and unbiased. I correct the problem by *robust* the regression model in STATA. The standard error after robust is reported in Table 4.4. It is clear that the standard errors are different.

Considering the time-specific and firm-specific effect on the investment model, I further analyze equation (4) which contains heterogeneity term. Both fixed-effect and random-effect models can be used to eliminate the heterogeneity term. As expected, the magnitude of outcome for each model is dissimilar. As shown in Table

4.5, fixed-effect model reports greater influence of cash flow on investment rate (0.157 to 0.145). However, Q presents the opposite outcome. Random-effect model estimates Q as more influential on investment rate (0.0923 to 0.091). All statistics reported are significant at 5% significance level.

Table 4.5 Fixed-effect and Random-effect Results

	Fixed-effect	Random-effect
CF	.1565072 (.0013759) [0.000]	.1450516 (.0012573) [0.000]
Q	.0905597 (.0015525) [0.000]	.0922503 (.0013119) [0.000]
_cons	-.1218717 (.0118449) [0.000]	-.0935973 (.0116485) [0.000]

Standard errors are reported in parentheses. P-values are reported in brackets.

Additionally, it is worth paying attention to the F statistics reported by fixed-effect model. F statistics determines whether it is appropriate to use fixed-effect model. The null hypothesis for the test is that pooled model (as the above analysis of OLS estimator) is appropriate thus it is not necessary to use fixed-effect model. Simple OLS would be sufficient. In the research, F statistics suggests to reject the null hypothesis and prefer fixed-effect model. Similarly, the test between pooled model and random-effect model give preference to random-effect model (see the statistics in Appendix). The problem here is to decide which model to believe. In theory, if the heterogeneity item is correlated with the independent variables, fixed-effect model should be preferred. Hausman test is suitable for the model selection. The null hypothesis for Hausman test is that independent variables and heterogeneity are not correlated. In other words, if null hypothesis is not rejected, one should use random-effect model. From the test statistics given by STATA, I reject the null hypothesis (prob > chi^2 = 0.000) and prefer fixed-effect model. Comparing with the pooled model, fixed-effect model reports greater effect of cash flow on investment rate (0.157 to 0.121). An implication for this is that after controlling time-specific and firm-specific effects, internal finance even significantly affects the investment decisions made by firms to greater extent.

After testing equation (4) by fixed-effect and random-effect models, I move forward to the third test technique which is first-differencing transformation. By first-differencing transformation, the heterogeneity term can be eliminated as well. It is noticeable that after first-differencing, the constant item is dropped from the model. In addition, serial correlation should be tested in order not to influence the coefficients estimated. I use Wooldridge's method to test panel data serial correlation (command *xtserial* in STATA). The null hypothesis is that there is no first-order autocorrelation. The test statistic rejects the null and concludes that autocorrelation problem exists. In order to generate BLUE estimator, I employ *cluster* to correct autocorrelation and *noc* to represent the absence of constant item. The result is reported in Table 4.6. Cash flow is estimated to have positive effect on investment with the value 0.133, which is smaller than the coefficient from fixed-effect model but greater than simple OLS. Q is reported to have positive effect on investment as well, which is the same as previous tests, while the magnitude is greater (0.101 compared with 0.088 from OLS and 0.091 from fixed-effect). All the coefficients are statistically significant. Compared with simple OLS, the prediction power is a little stronger for first-differencing transformed model, with an R-squared value of 0.4984.

Table 4.6 First-differencing Transformation Results

	Coef.	Std. err robust	P-value
D1.CF	.1328339	.002903	0.000
D1.Q	.1013758	.0019443	0.000

D1 means the variable is first differenced by itself lagged one period.

Finally, I test the investment-cash flow sensitivity by employing instrumental variable and GMM method. A reason for testing dynamic model using GMM is that it is concerned the change in current cash flow may not only affect current investment decisions, but also the decisions for the future. The dynamic model tested for this purpose is equation (7). Although dynamic panel data model allows researchers to create instrumental variables without requiring new data, the more instrumental variables generated, the more observations are lost. In addition, too many instrumental variables may bias GMM in small samples (Hill, Griffiths, and Lim 2008). Therefore, two instrumental variables which are *INV* lagged two and three periods are chosen. In order to utilize the instrumental variable, the chosen IV must be valid. The test statistics are reported in Appendix. Furthermore, there is one important assumption for IV to be valid, which is that the error term is not serially correlated. However, Wooldridge test shows that serial correlation does exist for the model. I hence use *cluster* command in STATA to correct the problem. Similar to first-differencing transformation, the constant item is eliminated from the model. The investment-cash flow relationship is reported in Table 4.7.

GMM reveals much smaller effect of cash flow on investment than first-differencing transformation with a value of 0.038. The p-value shows that the influence is significant. Q is estimated to have weaker positive effect on investment than reported by first-differencing transformation. The magnitude is 0.048 compared to 0.101. The p-value demonstrates that Q is statistically significant as well.

Furthermore, GMM also tests the effect of lagged investment rate. It reveals a significant strong positive effect (0.208) on current investment decision. The test statistics for overidentifying restrictions (Hansen's J) prefer the null hypothesis that all instruments are valid with chi-squared distribution of one degree of freedom and a p-value of 0.3543. The F statistic which is used to test weak instruments suggests no such error with a value of 13.85.

Table 4.7 GMM Results

	Coef.	Std. err robust	P-value
D1.CF	.0379426	.0057217	0.000
D1.Q	.0483893	.0028439	0.000
LD.INV	.207658	.0236257	0.000

D1 means the variable is first differenced by itself lagged one period. LD means lagged *INV* is first differenced.

For comparison, I gather the results from each test and export that in Table 4.8. All the tests carried out reveal positive effect of cash flow on investment rate. Fixed-effect model gives the highest estimation of investment-cash flow sensitivity at a value of 0.157. First-differencing transformation follows fixed-effect model with a value of 0.133. OLS estimation is 8.5% lower than first-differencing transformation. GMM reveals the lowest value of only 0.038. The most influential factor predicted by GMM is the lagged investment rate, reaching 0.208. Meanwhile, Q is found to positively affect investment as well, but with divergent magnitude. First-differencing transformation shows the highest effect. OLS and fixed-effect report middle range of effect whereas GMM exhibits lowest effect of Q. All the coefficients are strongly significant at 95% confidence interval.

Table 4.8 Comparison of Four Test Techniques

	OLS	Fixed-effect	First-differencing	GMM
CF	.1214746 (.0015914) [0.000]	.1565072 (.0013759) [0.000]	.1328339 (.002903) [0.000]	.0379426 (.0057217) [0.000]
Q	.0877112 (.0008871) [0.000]	.0905597 (.0015525) [0.000]	.1013758 (.0019443) [0.000]	.0483893 (.0028439) [0.000]
LD.INV				.207658 (.0236257) [0.000]

Standard errors are reported in parentheses. P-values are reported in brackets.

4.2.2 Answer to Question (2) and (3)

To study the difference of investment-cash flow sensitivity between constrained and unconstrained firms, I first use dividend as the criterion to split the sample. Similar to the processing of other variables, dividend rate is winsorized between 0 and 5. The mean for dividend rate is 0.162. In STATA, I create a dummy variable *DIV* to refer to dividend payment and 0 is defined as constrained (D_{div} in equation (10)). Company is given the value 0 if dividend rate is lower than average. The dummy variable is interacted with *CF* to estimate the effect on investment (DIV_CF in STATA and $D_{div} \times \left(\frac{CF_{it}}{K_{it-1}}\right)$ in equation (10)). The regression model to be run for this purpose is equation (10). I employ fixed-effect and IV/GMM to estimate the model. The results are reported in columns (1) and (2) in Table 4.9.

Table 4.9 Regression Results with Financial Constraints

	Dividend as financial constraint		Total assets as financial constraint		Sales as financial constraint	
	Fixed-effect	GMM	Fixed-effect	GMM	Fixed-effect	GMM
	(1)	(2)	(3)	(4)	(5)	(6)
CF	.1544544 (.0014208) [0.000]	.0263583 (.0054289) [0.000]	.2232757 (.0024305) [0.000]	.0228591 (.0120641) [0.058]	.1731248 (.0018419) [0.000]	.0311136 (.0089249) [0.000]
Q	.0906324 (.0015512) [0.000]	.0469957 (.0027335) [0.000]	.0718012 (.0016115) [0.000]	.0488345 (.0028803) [0.000]	.0885186 (.001552) [0.000]	.0482607 (.0028293) [0.000]
DIV_CF	.024833 (.0043461) [0.000]	.0886919 (.0085089) [0.000]				
DTA_CF			-.0898046 (.0027312) [0.000]	.0172131 (.011439) [0.132]		
DTS_CF					-.0330957 (.0024545) [0.000]	.0093374 (.0082895) [0.260]
LD.INV		.1942064 (.02285) [0.000]		.2066552 (.0236452) [0.000]		.2055418 (.2055418) [0.000]

Standard errors are reported in parentheses. P-values are reported in brackets.

Column (1) and (2) in Table 4.9 show the results from fixed-effect model and GMM respectively. The two techniques reveal dissimilar magnitude of sensitivity of cash flow on investment (0.154 to 0.026). The values are both positive and consistent with previous tests. It is worth noticing that this value is the sensitivity for constrained firms, where dividend dummy is set zero. From Fazzari *et al*'s point of view, unconstrained firms should be less sensitive which implies that dividend dummy should be negative. However, adverse results are found against Fazzari *et al*. As 1 stands for unconstrained firms in the dividend dummy, positive estimations of *Ddiv_cf* add value to the coefficient of *CF*. Unconstrained firms are found to be more sensitive than constrained ones by both fixed-effect and GMM techniques (0.179 from fixed-effect and 0.115 from GMM). Possible explanation is given in Moyen (2004). She claims that both constrained and unconstrained firms make investment when there is opportunity. Unconstrained firms even raise debt to finance the investment. However, the effect of debt financing is not captured by the investment model. It hence magnifies the investment-cash flow sensitivity of unconstrained firms. Moving forward to Q, fixed-effect model reports higher coefficient for Q than GMM (0.091 to 0.047). Lagged investment rate is again found positively affect current investment, although the magnitude is smaller than previous tests.

The prerequisite for fixed-effect model and GMM are tested as well. The F test for model choice prefers fixed-effect model than pooled model. Hence the coefficients from fixed-effect model are credible. In addition, the instrumental variables in GMM are found valid with 0.3525 p-value for J-test. There is no evidence for weak instrument and all the instrumental variables are significant.

Secondly, I will test the model by dividing the sample according to firm size. Two criterions are employed which are total assets and sales. Both of them are winsorized between 0 and 10 to avoid outlier effect. Similar to the process for dividend rate, I calculate the mean for total assets rate and sales rate. Companies are considered as small if the total assets rate or sales rate are lower than average. Small firms are valued 0 in the dummy variable (*DTA* and *DTS*), which is then interacted with cash flow (*DTA_CF* and *DTS_CF* in STATA). Fixed-effect model and GMM are used sequentially. The results are shown in columns (3) to (6) in Table 4.9.

When employing total assets as the splitting criterion, some consistent results present, but also some ones different from dividend criterion. Positive sensitivity is found to constrained firms both by fixed-effect and GMM (0.223 and 0.023 respectively). Q is also reported to positively affecting investment (0.072 and 0.049). Considering unconstrained firms, two different techniques reveal different results. Fixed-effect model reports lower sensitivity of investment to cash flow (0.133), which supports Fazzari *et al'*s argument that unconstrained firms are less sensitive. The result is reported as significant. By contrast, GMM reports that unconstrained firms are more constrained at a value of 0.040. Although this is consistent with the findings on dividend, the figure is found statistically insignificant. Therefore, GMM result should not be believed. Therefore, constrained firms are found more sensitive than unconstrained ones if the sample is split by total assets. All the prerequisites for instruments are tested and no deniable evidence is found.

Columns (5) and (6) in Table 4.9 shows the sensitivity when using sales as the criterion to separate firms. Identical to previous researches, both fixed-effect model and GMM give positive effect of cash flow on investment for constrained firms (0.173 and 0.031 respectively), the same for Q (0.089 and 0.048). For unconstrained firms, fixed-effect and GMM again, reveal different results. Similar to the test on total assets, fixed-effect estimate unconstrained firms to be less sensitive with a value of 0.140. By contrary, GMM gives higher sensitivity level to unconstrained firms (0.040). In other words, fixed-effect model supports Fazzari *et al'*s findings while GMM prefers Kaplan and Zingales'*.* However, it is noticed that the dummy variable is insignificant in GMM once again. Besides, all the other coefficients are found significant. The lagged investment rate is robust and consistent with previous tests. Lastly, the prerequisites for instruments are tested and all of the instruments are valid.

Furthermore, I try to split the sample by interacting two dummy variables. *DX1* is created to represent the interactive dummy of dividend and total assets multiplied by *CF* [$D_{div} \times D_{ta} \times \left(\frac{CF_{it}}{K_{it-1}}\right)$], and *DX2* stands for dividend and sales dummy multiplied by *CF* [$D_{div} \times D_{ts} \times \left(\frac{CF_{it}}{K_{it-1}}\right)$]. The results are reported in Table 4.10.

Table 4.10 Regression Results by Interactive Dummy Variable

	Dividend and Total Assets Interacted		Dividend and Sales Interacted	
	Fixed-effect	GMM	Fixed-effect	GMM
	(1)	(2)	(3)	(4)
CF	.2211761 (.0024575) [0.000]	.0191146 (.0118968) [0.108]	.1715116 (.0018625) [0.000]	.0306848 (.008827) [0.001]
Q	.0713408 (.0016083) [0.000]	.0471591 (.0027763) [0.000]	.0884047 (.001549) [0.000]	.0470208 (.0027306) [0.000]
DDIV_CF	.0684141 (.010546) [0.000]	.0912642 (.0089055) [0.000]	.0529573 (.0095066) [0.000]	.062415 (.0397653) [0.117]
DTA_CF	-.0915262 (.0028058) [0.000]	.0083576 (.0114163) [0.464]		
DTS_CF			-.0358918 (.0025586) [0.000]	-.0065572 (.0087925) [0.456]
DX1	-.0308336 (.0113938) [0.007]	-.0078749 (.0050378) [0.118]		
DX2			-.0201455 (.0106048) [0.057]	.0307786 (.0407359) [0.450]
LD.INV		.1879015 (.1879015) [0.000]		.1942904 (.0229453) [0.000]

Standard errors are reported in parentheses. P-values are reported in brackets.

The finding from the last test is interesting. For columns (1) and (2) in Table 4.10, Q is found to be positive and significant by both techniques. Additionally, both of the models give positive effect of cash flow on investment for most constrained firms (small and low dividend payment). Similar to previous tests, fixed-effect model reports greater sensitivity level than GMM (0.221 to 0.019). However, cash flow is found insignificant by GMM. Nevertheless, this test contains more information. Firms are grouped into four categories, which are small firms paying low dividend, small firms paying high dividend, large firms paying low dividend, and large firms paying high dividend. For each type, the sensitivity is found different (see Table 4.11).

Table 4.11 Investment-Cash Flow Sensitivity for Four Firm Categories

	dividend and total assets interacted		dividend and sales interacted	
	Fixed-effect model	GMM	Fixed-effect model	GMM
	(1)	(2)	(3)	(4)
Small firms paying low dividend	.2211761	.0191146 *	.1715116	.0306848
Small firms paying high dividend	.2895902	.0912642	.2244689	.0930998 *
large firms paying low dividend	.1296499	.0274722 *	.1356198	.0241276 *
large firms paying high dividend	.159728	.1108615 *	.1684316	.1173212 *

* stands for insignificant value at 5% significance level.

For the first column in table 4.11, the reports from fixed-effect model show that the most sensitive firms come from relatively constrained category with a coefficient of 0.290, while the least sensitive firms are from the same category, large firms with low dividend payment (0.130). Firms who pay high dividend are estimated more sensitive, regardless of firm size. For firms paying similar level of dividend (high or low), small firms are always more sensitive, which reveals the findings of the test on firm size independently. Surprisingly, GMM finds cash flow as insignificant estimator of investment. The only significant estimator for the four categories is the coefficient for small firms paying high dividend (0.091). As the other variables are all insignificant, the results cannot be compared. Another significant estimator is the lagged investment rate. It is reported at a significant value of 0.188. All the conditions for model fitness are tested. I find no problem for fixed-effect model and the instrumental variables are valid and significant.

Columns (3) and (4) in Table 4.10 and Table 4.11 report the results for dividend dummy interacted with sales dummy. Q is found positive and significant by the two techniques (0.088 and 0.047 respectively). Similar to columns (1) and (2) in Table 4.11, most and least sensitive firms both come from relative constrained category. Small firms paying high dividend are most sensitive with a value of 0.224 while large firms paying low dividend are least sensitive with a value of 0.136. Once again, firms paying high dividend are found more sensitive no matter how the size is categorized, small or large. Additionally, small firms are more sensitive all the time for high or low dividend payment level. In comparison, GMM reveals significant value for small firms paying low dividend only. Again, no significant values for the other three categories are found and hence the results could not be compared. Lagged investment rate is estimated statistically significant at 0.117. Finally, I find no problem for model fitness. All preconditions are satisfied.

To conclude, the outcome for two dummy variables interacted is clear. Two different measurements of firm size reveal identical results. Large firms paying low dividend is found to be most sensitive, with small firms paying high dividend least sensitive. Dividend is found as an influential indicator that sheds light on investment-cash flow sensitivity. Using dividend as measurement of financial constraint will lead to Kaplan and Zingales' results, without considering the effect of firm size. By contrast, Fazzari *et al*'s finding is confirms by using firm size as the measure of financial constraint, regardless the dividend payment level. Nevertheless, GMM is found to be a weak method in this research as the coefficients from GMM is always insignificant.

Table 4.12 Variable Correlation—Dividend Payment

	Firms with low dividend payment					
	INV	*CF*	*Q*	*DIV*	*TA*	*TS*
Mean:	.6070973	.2890828	7.333354	.014212	6.319998	5.31117
Correlation:						
INV	1.0000					
CF	0.5339	1.0000				
Q	0.4754	0.0989	1.0000			
DIV	-0.1000	0.1020	-0.1215	1.0000		
TA	0.0982	-0.1481	0.5723	-0.2032	1.0000	
TS	-0.0247	0.1040	0.2296	-0.0242	0.5450	1.0000
	Firms with high dividend payment					
Mean:	.7741144	1.826009	8.96838	1.681852	7.886085	7.525978
Correlation:						
INV	1.0000					
CF	0.7381	1.0000				
Q	0.3537	0.3308	1.0000			
DIV	0.5091	0.2614	0.1285	1.0000		
TA	0.2731	0.1522	0.3186	0.5281	1.0000	
TS	0.2342	0.2208	0.1788	0.5126	0.6805	1.0000

Finally, following Moyen (2004), I test the correlation between variables used in previous researches, and try to explain investment-cash flow sensitivity from a broader context. The correlation of variables for firms whose financial status is grouped by dividend payment is reported in Table 4.12. According to the table, low dividend payers make fewer investments than high dividend payers with mean of 0.607 to 0.774. Meanwhile, the relationship between investment rate and dividend payment for firms paying low dividend is negative, indicating that such firms have to choose between investment and dividend payment for limited internal capital, thus they are relatively constrained.

Table 4.13 shows the variable correlation of firms divided by total assets. As expected, large firms are reported to make more investment (0.706 to 0.539). However, small firms seem to generate more cash flow than large ones. The reason might be that they pay fewer dividends (0.039 on average). Moreover, they may not invest in fixed assets which in this research is the definition of investment, but in some other field, for example profitable projects, to make the company grow faster, which further explains why small firms have low investment rate but high cash flow. On the other hand, identical to Table 4.12, small firms reveal negative relationship between investment and dividend payment. By contrast, those two are positively correlated for large firms. Additionally, cash flow and dividend payment is positively correlated as well, implying that large firms are less likely to be financially constrained.

Sales is the last criterion used to measure financial constraints and the results are reported in Table 4.14. In general, small firms with less sales make similar investments as large ones (0.607 to 0.639), but lower cash flow (0.163 to 0.726). The dividend payment from small firms is also lower with an average of 0.036 compared with 0.306 for large ones. Identical to previous analysis, the relationship between cash flow and investment for small firm is estimated negative, which applies that small firms are likely constrained. By contrast, large firms pay more dividends when there is an increase in cash inflow. Meanwhile, large firms make more investment with the increase of cash inflow. It seems that large firms care less about controlling their internal capital. Hence large firms are considered as relatively less constrained.

Table 4.13 Variable Correlation—Total Assets

	Firms with low total assets					
	INV	*CF*	*Q*	*DIV*	*TA*	*TS*
Mean:	.5390684	.7280712	5.80398	.0391257	3.560911	3.788709
Correlation:						
INV	1.0000					
CF	0.7028	1.0000				
Q	0.6142	0.3587	1.0000			
DIV	-0.0228	0.0810	0.1083	1.0000		
TA	-0.0104	-0.0065	0.3501	0.1363	1.0000	
TS	-0.0678	0.1096	0.0594	0.1405	0.5472	1.0000
	Firms with high total assets					
Mean:	.706439	.1158894	9.187387	.2871726	9.417217	7.261887
Correlation:						
INV	1.0000					
CF	0.5119	1.0000				
Q	0.2898	0.0982	1.0000			
DIV	0.2225	0.1926	0.0246	1.0000		
TA	0.1066	-0.0626	0.2376	0.1122	1.0000	
TS	-0.0462	0.2605	-0.0831	0.1754	0.1322	1.0000

Table 4.14 Variable Correlation—Sales

	Firms with low sales					
	INV	*CF*	*Q*	*DIV*	*TA*	*TS*
Mean:	.6067996	.1629426	6.674259	.0358036	4.835309	2.575539
Correlation:						
INV	1.0000					
CF	0.5521	1.0000				
Q	0.5396	0.0624	1.0000			
DIV	-0.0179	0.0458	0.0502	1.0000		
TA	0.1221	-0.2984	0.5453	0.0394	1.0000	
TS	-0.1259	0.2172	-0.0887	0.0962	-0.0212	1.0000
	Firms with high sales					
Mean:	.6391714	.725646	8.399296	.3063171	8.318932	8.866878
Correlation:						
INV	1.0000					
CF	0.5587	1.0000				
Q	0.3826	0.1798	1.0000			
DIV	0.2625	0.1861	0.0899	1.0000		
TA	0.1402	-0.0365	0.4987	0.1629	1.0000	
TS	0.1053	0.0032	0.2481	0.1635	0.5496	1.0000

4.3 Discussion

Based on the above tests, I find that internal finance does influence firms' investment decisions. All of the four test techniques confirm that cash flow positively and significantly affect investment rate, although the reported magnitude is not constant. Fixed-effect model reports the greatest sensitivity of investment on cash flow while GMM estimates the lowest coefficient for that relationship. First-differencing transformation and OLS give similar magnitude.

Additionally, using three different separating criterions, I divide the firms into constrained and unconstrained groups. Dividend payment is firstly tested. Surprisingly, the findings are contrary to Fazzari *et al's* results and in favour of Kaplan and Zingales'. The difference of sensitivity between the two groups is not huge. Firms paying high dividend is reported to be more sensitive than those paying low dividend. Moyen (2004) explains that unconstrained firms finance their investment not only by internal capital, but also debt. However, the debt effect is not captured by the model. Therefore, the sensitivity of unconstrained firms is magnified. In addition, unconstrained firms bear greater burden from interest payment. Bondholders are willing to influence firms' investment behaviour by raising covenant (Smith and Warner 1979), which makes unconstrained firms more sensitive to the availability of internal capital. The two test techniques reveal similar trends. Secondly, I try to split the sample by firm size. Two measurements, total assets and sales, reveal identical results. However, no matter which criterion is employed, constrained firms always tend to be more sensitive, which supports Fazzari *et al*. Literature concludes that small firms are usually developing fast and in great need of capital. As it is difficult for small firms to get access to external finance, due to their creditability and profitability, internal finance is essential for the growth of small firms. Furthermore, the correlation analysis followed confirms that small firms have to choose between dividend payment and investment. Therefore, small firms should be more constrained and sensitive. Between the two econometric techniques utilized, GMM fails to report significant value on the dummy variables created. Therefore, the above results are mainly from fixed-effect model.

Following the test for financial constraints by only one indicator, I try to split the firms by two interacted indicators. Firms are divided into small paying low dividend (most constrained), small paying high dividend (relatively constrained), large paying low dividend (relatively constrained), and large paying high dividend (most unconstrained). By modifying the measurement of financial constraints, some different results appear. Fixed-effect model find that relatively constrained firms are most sensitive, regardless whether the constraints are dividend interacted by total assets or by sales. It is always more sensitive for firms with high dividend payment regardless of firm size and for small firms regardless of dividend payout level. All of the test statistics from fixed-effect model are significant. However, when GMM is employed, insignificant values appear. Although there are other papers deriving insignificant values from GMM (Huang n.d., and Ağca and Mozumdar 2005), all insignificant values are dropped out of the comparison between constrained and unconstrained firms.

4.4 Limitations

I have noticed several limitations in this research. Firstly, the sample is imperfect. As shown in the data description, the chosen data is unbalanced. Many companies may not report full information for the entire sample period, which could bias the outcome. Secondly, the reported statistics may not be exactly accurate and may be biased. Although I have processed the data to some extent, lacking of experience will lead to insufficient data handling, which could further affect the accuracy of the outcomes. In addition, as the sample period covers macro economic depression caused by subprime crisis, cash flow is significantly affect by this recession and could generate abnormal outcomes. Even though econometric techniques are helpful to reduce the effect of such time-specific influence, the impact on data accuracy and reliability is not predictable. Finally, there is not standardized calculation of variables used in investment models. Different researchers carry out different ways of calculating investment, cash flow and average Q, which could factitiously affect the results. I try to use the widely accepted definitions of calculation and reduce such effects. However, the use of average Q itself is problematic as average Q cannot substitute marginal Q. Further effort could be made to produce better indicator for investment opportunities than average Q.

CHAPTER Ⅴ CONCLUSION

The debate between Fazzari, Hubbard and Petersen (1988) and Kaplan and Zingales (1997) on investment-cash flow sensitivity has driven many researchers studying this topic. In this thesis, I try to illustrate the problem by answering three research questions, which are:

(1) Does the availability of internal finance affect firms' investment behaviour?

(2) To what extent does internal finance affect investment levels of financially constrained and unconstrained firms?

(3) Will different measurement of financial constraints affect the outcome?

To answer these questions, I employ Tobin's Q investment model, which is widely used by empirical researches on investment-cash flow sensitivity problem. The model is firstly developed by Fazzari, Hubbard and Petersen (1988). In theory, the model uses Tobin's marginal Q to capture future investment opportunity and examines the effect of cash flow on firms' investment. However, as marginal Q is not observable, empirical studies usually use average Q instead, which by definition, is the market value divided by book value of fixed assets. I borrow the same definition in this study. Cash flow and investment are divided by capital stock at the beginning of each period to set each observation at the same benchmark level.

Using panel data from 2,233 American manufacturing companies obtained from COMPUSTAT North America database, the sample is formed by 20,511 firm-year observations. The sample period is set to be 10 years, covering 1999 to 2008. Data is winsorized to eliminate the effect of extreme values. The guideline is taken from Moyen (2004) as follows: investment between 0 and 2, cash flow between -5 and 5, Q between 0 and 10, dividend rate between 0 and 5, total assets between 0 and 10, and sales between 0 and 10. Several econometric techniques are applied to test the regression models, including simple OLS, fixed-effect (within) model, first-differencing transformation and instrumental variables by General Method of

Moments (GMM). The assumptions and prerequisite conditions for each technique are examined to make sure the estimated coefficients are free from any bias.

The findings for the effect of cash flow on investment consist with previous literatures. All the four tests find that internal finance has positive effect on investment decisions and the coefficients are statistically significant, although the scale is divergent. Fixed-effect model reports the highest sensitivity. First-differencing transformation and OLS reveal similar middle scale and the lowest estimation comes from GMM.

The study also shows that different measurements of financial constraints do affect the outcome of investment-cash flow sensitivity. To study the difference between constrained and unconstrained firms, dividend and firm size are utilized as the splitting criterion. Firms with lower-than-average dividend payment are considered as constrained, otherwise unconstrained. Firm size is determined by two indicators, which are total assets and sales. Companies with lower-than-average total assets (sales) are taken as small and thus financially constrained. Dummy variables are created to label different firms from the two groups. Value 1 stands for unconstrained firms (high dividend payment, high total assets or high sales) while 0 is given to constrained ones. Fixed-effect model and GMM are employed to test the sensitivity of constrained and unconstrained firms. In general, the findings are divergent based on different splitting standard. Firms with low dividend payment are found to be less sensitive, which is against the findings of Fazzari *et al*. The magnitude is reported in Table 5.1 and the explanation is given in the following context. However, if firms are divided by total assets, the results turn to be consistent with Fazzari *et al*. All the coefficients in the test on dividend criterion and firm size criterions are statistically significant given by fixed-effect model, including the dummy variable, whereas firm size dummies are reported insignificant by GMM. Additionally, GMM reveals significant coefficients for lagged investment rate.

Table 5.1 Conclusive Magnitude by Different Splitting Criterions

	Dividend	Total assets	Sales
Constrained firms	(.1544544) [.0263583]	(.2232757) [.0228591]	(.1731248) [.0311136]
Unconstrained firms	(.1792874) [.1150502]	(.1334711) [.0400722] *	(.1400291) [.040451] *

The coefficients from fixed-effect model are reported in parenthesis. The coefficients from GMM are reported in brackets. * stands for insignificant value.

Besides separating the sample by only one indicator, dividend and firm size are interacted to split the firms. Two individual dummy variables (dividend dummy and firm size dummy) and one interactive dummy are added into the regression model for testing. Accordingly, the firms are divided into four groups, which are small firm with low dividend payment (most constrained), small firms with high dividend payment (relatively constrained), large firms with low dividend payment (relatively constrained) and large firms with high dividend payment (most unconstrained). Fixed-effect method shows that firms with high dividend payment are more sensitive to cash flow, no matter how firm size is sorted. A possible explanation could be that unconstrained firms borrow debt to finance their investment in addition to internal capital. However, the debt effect on investment is not measured in the investment model and hence the sensitivity of cash flow is enlarged (Moyen 2004). Meanwhile, such firms bear heavy burden of interest payment, and thus existing bondholders will prevent the firms from issuing new debt. Therefore, unconstrained firms appear to be more sensitive to internal capital. This also explains the outcome of the test on dividend payment independently. Nevertheless, small firms are always more sensitive in the categories grouped by dividend. In other words, in the high dividend payment group, small firms reveal stronger sensitivity. The same is found in low dividend payment group. All the coefficients are statistically significant. By contrast, GMM fails to report meaningful statistics in this research. All the dummy variables are found insignificant. Therefore, GMM may not be a suitable method for this study.

Finally, following Moyen (2004), the correlation matrix of variables is generated to analyze the investment behaviour in a more general context. For all the three splitting criterions, unconstrained firms reveal higher investment than constrained ones. All the tests of correlations reveal that the relationship between dividend payment and investment for small firms are negative, which proves that small firms have to choose between paying dividend and making investment if they have extra cash. Thus small firms are relatively more constrained. Surprisingly, small firms are found to make higher cash flow on average if grouped by total assets. The reason could be that small firms pay fewer dividends and they would invest in other profitable projects rather than fixed assets, in seeking for better growth in the future. Small firms develop fast and it is common to pay low dividend.

There are limitations in this study, including unbalanced data, inefficient data handling and non-uniform approach to calculate variables used in the regression model. The use of average Q is also problematic. Further researches are expected to improve the accuracy of dataset and better calculation of Tobin’s Q. Meanwhile, the choice of suitable test techniques is important as well. Different techniques have been proved to give divergent results.

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APPENDIX:

1. Data Items:

Financial Statement:	Item:	Symbol in STATA:
Cash Flow Statement:	Capital Expenditures	*CAPX*
	Cash Dividends	*DV*
	Deferred Taxes	*TXDC*
	Depreciation and Amortization	*DPC*
	Income before Extraordinary Items	*IBC*
Balance Sheet:	Assets—Total	*AT*
	Depreciation, Depletion and Amortization (Accumulated)	*DPACT*
	Long-term Debt—Total	*DLTT*
	Property, Plant and Equipment —Total (Gross)	*PPEGT*
	Property, Plant and Equipment —Total (Net)	*PPENT*
Income Statement:	Sales/Turnover (Net)	*SALE*
Supplemental Data Items:	Price Close—Annual—Fiscal	*PRCC_F*
Miscellaneous Items:	Common Shares Outstanding	*CSHO*

2. Raw Data Description:

Variable	Obs	Mean	Std. Dev.	Min	Max
gvkey	20511	52255.98	56032.95	1013	287882
datadate	20511	16295.06	1036.516	14425	18048
fyear	20511	2003.66	2.829856	1999	2008
at	20511	2762.345	14399.66	0	448507
bkvlps	20511	115.9348	14796.28	-1843.915	2117000
capx	20511	149.9754	1036.18	-.105	40595.29
che	20511	303.8337	1600.879	0	54987
csho	20511	117.9997	492.2261	.001	23177.63
dltt	20511	515.6103	3565.487	0	191133
dpact	20511	790.8469	4891.045	0	159471
dpc	20511	126.9381	768.7119	0	44667
dv	20511	56.94581	379.1149	-.042	10342
ibc	20511	139.6217	1136.959	-24474	45220
lt	20511	1678.125	10530.57	0	422932
ppegt	20511	1592.113	9683.478	0	280340
ppent	20511	801.2666	4976.061	0	121346
sale	20511	2436.452	13041.14	-.234	425071
txdb	20511	101.5814	816.4266	-.313	22899
txdc	20511	-.5187	115.5974	-5477	4283
prcc_f	20511	15.57192	25.68142	.0001	983.02

3. Test: OLS

```
. regress  inv cf q

      Source |       SS       df       MS              Number of obs = 20511
-------------+------------------------------           F(  2, 20508) =8914.61
       Model |  5195.63216     2  2597.81608           Prob > F      =  0.0000
    Residual |  5976.26136 20508  .291411223           R-squared     =  0.4651
-------------+------------------------------           Adj R-squared =  0.4650
       Total |  11171.8935 20510  .544704706           Root MSE      =  .53983

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1214746   .0012449    97.57   0.000     .1190344    .1239148
           q |   .0877112   .0011267    77.85   0.000     .0855028    .0899195
       _cons |  -.0856756    .009183    -9.33   0.000     -.103675   -.0676762
------------------------------------------------------------------------------

. regress  inv cf q, robust

Linear regression                                      Number of obs = 20511
                                                       F(  2, 20508) =10241.71
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.4651
                                                       Root MSE      =  .53983

------------------------------------------------------------------------------
             |               Robust
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1214746   .0015914    76.33   0.000     .1183553    .1245939
           q |   .0877112   .0008871    98.88   0.000     .0859725    .0894499
       _cons |  -.0856756   .0043605   -19.65   0.000    -.0942225   -.0771286
------------------------------------------------------------------------------
```

a) Test of Multicollinearity:

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
          cf |      1.02    0.983474
           q |      1.02    0.983474
-------------+----------------------
    Mean VIF |      1.02

. correlate inv cf q
(obs=20511)

             |      inv       cf        q
-------------+---------------------------
         inv |   1.0000
          cf |   0.5541   1.0000
           q |   0.4655   0.1286   1.0000
```

b) Test of Heteroscedasticity:

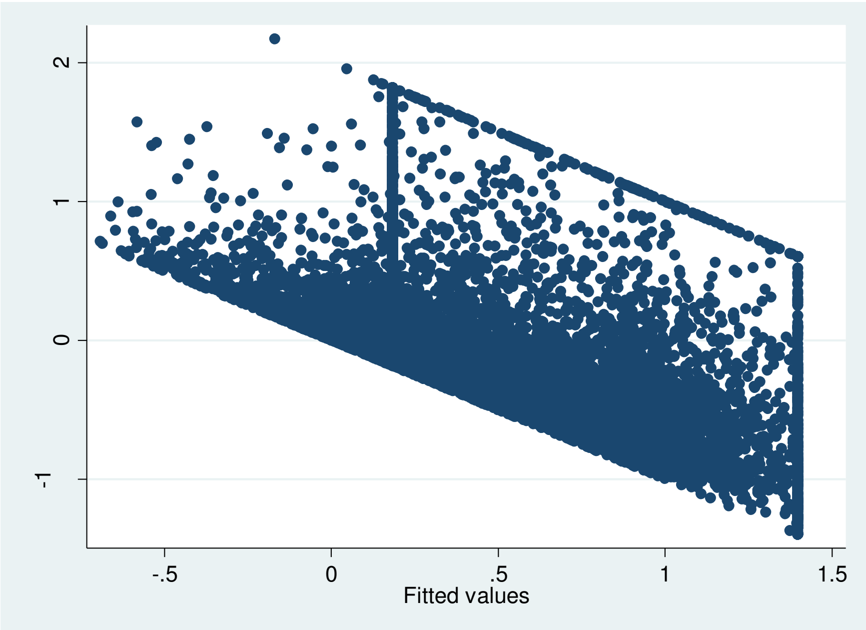
```
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(5)      =    3051.07
         Prob > chi2  =     0.0000

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	3051.07	5	0.0000
Skewness	3303.45	2	0.0000
Kurtosis	180.81	1	0.0000
Total	6535.34	8	0.0000



c) Test for Autocorrelation:

```
. xtserial  inv cf q

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     2511) =    226.573
           Prob > F =      0.0000
```

4. Test: Fixed-effect and Random-effect

a) Fixed-effect Model:

```
. xtreg  inv cf q , fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                          Number of groups   =      2825

R-sq:  within  = 0.5836                        Obs per group: min =         1
       between = 0.3497                                       avg =       7.3
       overall = 0.4611                                       max =        10

                                               F(2,17684)         =  12392.20
corr(u_i, Xb)  = -0.2813                       Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1565072   .0013759   113.75   0.000     .1538103     .159204
           q |   .0905597   .0015525    58.33   0.000     .0875166    .0936028
       _cons |  -.1218717   .0118449   -10.29   0.000    -.1450888   -.0986545
-------------+----------------------------------------------------------------
     sigma_u |  .36583271
     sigma_e |  .45863916
         rho |  .38884372   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17684) =     3.80         Prob > F = 0.0000
```

b) Random-effect Model:

```
. xtreg  inv cf q , re

Random-effects GLS regression                   Number of obs      =     20511
Group variable: gvkey                          Number of groups   =      2825

R-sq:  within  = 0.5831                        Obs per group: min =         1
       between = 0.3581                                       avg =       7.3
       overall = 0.4637                                       max =        10

Random effects u_i ~ Gaussian                  Wald chi2(2)       =  24741.52
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1450516   .0012573   115.37   0.000     .1425873    .1475159
           q |   .0922503   .0013119    70.32   0.000     .0896789    .0948216
       _cons |  -.0935973   .0116485    -8.04   0.000    -.1164279   -.0707667
-------------+----------------------------------------------------------------
     sigma_u |  .27529735
     sigma_e |  .45863916
         rho |  .26486694   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

c) Hausman Test:

```
. hausman fixed

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed          .           Difference          S.E.
-------------+----------------------------------------------------------------
          cf |    .1565072     .1450516        .0114556        .0005587
           q |    .0905597     .0922503       -.0016906        .0008301
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      773.46
                Prob>chi2 =      0.0000
```

d) Test between Pooled and Random-effect Model:

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        inv[gvkey,t] = Xb + u[gvkey] + e[gvkey,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                     inv |   .5447047       .7380411
                       e |   .2103499       .4586392
                       u |   .0757886       .2752974

        Test:   Var(u) = 0
                             chi2(1) =  3965.60
                         Prob > chi2 =     0.0000
```

5. Test: First-differencing Transformation

```
. reg d.inv d.q d.cf, noc robust cluster (gvkey)

Linear regression                                      Number of obs =  17287
                                                       F(  2,  2721) = 7302.54
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.4984
                                                       Root MSE      =  .57206

                               (Std. Err. adjusted for 2722 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           q |
         D1. |   .1013758   .0019443    52.14   0.000     .0975633    .1051883
          cf |
         D1. |   .1328339    .002903    45.76   0.000     .1271415    .1385263
------------------------------------------------------------------------------
```

6. Test : Instrumental Variable by GMM

```
Instrumental variables (GMM) regression              Number of obs = 11739
                                                     Wald chi2(3)  =     .
                                                     Prob > chi2   =     .
                                                     R-squared     =     .
GMM weight matrix: Cluster (gvkey)                   Root MSE      =.49751

                               (Std. Err. adjusted for 2288 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inv |
         LD. |    .207658   .0236257     8.79   0.000     .1613525    .2539635
          cf |
         D1. |   .0379426   .0057217     6.63   0.000     .0267282     .049157
           q |
         D1. |   .0483893   .0028439    17.02   0.000     .0428154    .0539633
------------------------------------------------------------------------------
Instrumented:  LD.inv
Instruments:   D.cf D.q L2.inv L3.inv
```

a) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .858087 (p = 0.3543)
```

b) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv, robust noc

Linear regression                                     Number of obs = 11739
                                                    F(  4, 11735) = 375.74
                                                    Prob > F      = 0.0000
                                                    R-squared     = 0.2567
                                                    Root MSE      = .41618

------------------------------------------------------------------------------
             |               Robust
      LD.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |
         D1. |  -.0215254   .0031402    -6.85   0.000    -.0276807     -.01537
           q |
         D1. |  -.0239786   .0020566   -11.66   0.000    -.0280099   -.0199474
         inv |
         L2. |  -.4888225   .0130485   -37.46   0.000    -.5143997   -.4632453
         L3. |   .1008423   .0049727    20.28   0.000     .0910951    .1105896
------------------------------------------------------------------------------

. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11735) =  702.09
            Prob > F =    0.0000
```

7. Test: Dividend Criterion

a) Fixed-effect Model:

```
. xtreg  inv cf q Ddiv_cf, fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                           Number of groups   =      2825

R-sq:  within  = 0.5844                         Obs per group: min =         1
       between = 0.3546                                        avg =       7.3
       overall = 0.4629                                        max =        10

                                                F(3,17683)         =   8287.14
corr(u_i, Xb)  = -0.2866                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1544544   .0014208   108.71   0.000     .1516694    .1572393
           q |   .0906324   .0015512    58.43   0.000     .0875919    .0936728
     Ddiv_cf |    .024833   .0043461     5.71   0.000     .0163142    .0333518
       _cons |  -.1255572   .0118519   -10.59   0.000    -.1487881   -.1023264
-------------+----------------------------------------------------------------
     sigma_u |  .36544457
     sigma_e |   .4582293
         rho |  .38876411   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17683) =     3.78         Prob > F = 0.0000
```

b) Instrumental Variable by GMM:

```
Instrumental variables (GMM) regression                Number of obs = 11739
                                                       Wald chi2(4)  =     .
                                                       Prob > chi2   =     .
                                                       R-squared     =     .
GMM weight matrix: Cluster (gvkey)                     Root MSE      = .4887

                                 (Std. Err. adjusted for 2288 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inv |
         LD. |   .1942064     .02285     8.50   0.000     .1494212    .2389916
          cf |
         D1. |   .0263583   .0054289     4.86   0.000      .015718    .0369987
           q |
         D1. |   .0469957   .0027335    17.19   0.000      .041638    .0523533
     Ddiv_cf |
         D1. |   .0886919   .0085089    10.42   0.000     .0720148     .105369
------------------------------------------------------------------------------
Instrumented:  LD.inv
Instruments:   D.cf D.q D.Ddiv_cf L2.inv L3.inv
```

c) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .864581 (p = 0.3525)
```

d) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv d.Ddiv_cf, robust noc

Linear regression                                      Number of obs = 11739
                                                     F(  5, 11734) =  312.86
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.2601
                                                     Root MSE      =  .41525

------------------------------------------------------------------------------
             |               Robust
      LD.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |
         D1. |  -.0172737   .0034473    -5.01   0.000     -.024031   -.0105164
           q |
         D1. |   -.023567   .0020753   -11.36   0.000    -.0276349   -.0194991
         inv |
         L2. |  -.4912642   .0129214   -38.02   0.000    -.5165923   -.4659361
         L3. |   .1013165   .0049607    20.42   0.000     .0915926    .1110403
     Ddiv_cf |
         D1. |   -.033782   .0078541    -4.30   0.000    -.0491773   -.0183867
------------------------------------------------------------------------------

. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11734) =  723.25
            Prob > F =    0.0000
```

8. Test: Total Assets Criterion

a) Fixed-effect Model:

```
. xtreg  inv cf q Dta_cf, fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                           Number of groups   =      2825

R-sq:  within  = 0.6076                         Obs per group: min =         1
       between = 0.3076                                        avg =       7.3
       overall = 0.4715                                        max =        10

                                                F(3,17683)         =   9126.48
corr(u_i, Xb)  = -0.2394                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .2232757   .0024305    91.86   0.000     .2185117    .2280398
           q |   .0718012   .0016115    44.55   0.000     .0686424    .0749599
      Dta_cf |  -.0898046   .0027312   -32.88   0.000     -.095158   -.0844511
       _cons |  -.0048308   .0120373    -0.40   0.688     -.028425    .0187634
-------------+----------------------------------------------------------------
     sigma_u |  .37512987
     sigma_e |   .4452427
         rho |   .4151551   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17683) =     4.02         Prob > F = 0.0000
```

b) Instrumental Variable by GMM:

```
Instrumental variables (GMM) regression                Number of obs = 11739
                                                       Wald chi2(4)  =     .
                                                       Prob > chi2   =     .
                                                       R-squared     =     .
GMM weight matrix: Cluster (gvkey)                     Root MSE      =  .497

                              (Std. Err. adjusted for 2288 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inv |
         LD. |   .2066552   .0236452     8.74   0.000     .1603114     .252999
          cf |
         D1. |   .0228591   .0120641     1.89   0.058    -.0007861    .0465043
           q |
         D1. |   .0488345   .0028803    16.95   0.000     .0431892    .0544797
      Dta_cf |
         D1. |   .0172131    .011439     1.50   0.132     -.005207    .0396332
------------------------------------------------------------------------------
Instrumented:  LD.inv
Instruments:   D.cf D.q D.Dta_cf L2.inv L3.inv
```

c) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .777063 (p = 0.3780)
```

d) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv d.Dta_cf, robust noc

Linear regression                                      Number of obs = 11739
                                                     F(  5, 11734) =  300.51
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.2569
                                                     Root MSE      =  .41616

------------------------------------------------------------------------------
             |               Robust
      LD.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |
         D1. |  -.0259915   .0076831    -3.38   0.001    -.0410517   -.0109313
           q |
         D1. |   -.023843   .0020858   -11.43   0.000    -.0279314   -.0197545
         inv |
         L2. |  -.4887727   .0130492   -37.46   0.000    -.5143514   -.4631941
         L3. |   .1008981    .004975    20.28   0.000     .0911464    .1106499
      Dta_cf |
         D1. |   .0051096   .0075402     0.68   0.498    -.0096703    .0198896
------------------------------------------------------------------------------

. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11734) =  701.87
            Prob > F =    0.0000
```

9. Test: Sales Criterion

a) Fixed-effect Model:

```
. xtreg  inv cf q Dts_cf, fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                          Number of groups   =      2825

R-sq:  within  = 0.5878                        Obs per group: min =         1
       between = 0.3439                                       avg =       7.3
       overall = 0.4630                                       max =        10

                                               F(3,17683)         =   8406.55
corr(u_i, Xb)  = -0.2681                       Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1731248   .0018419    93.99   0.000     .1695144    .1767351
           q |   .0885186    .001552    57.03   0.000     .0854764    .0915607
      Dts_cf |  -.0330957   .0024545   -13.48   0.000    -.0379067   -.0282847
       _cons |  -.1024819   .0118722    -8.63   0.000    -.1257526   -.0792112
-------------+----------------------------------------------------------------
     sigma_u |  .36591935
     sigma_e |  .45631221
         rho |  .39137679   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17683) =     3.84         Prob > F = 0.0000
```

b) Instrumental Variable by GMM:

```
Instrumental variables (GMM) regression                Number of obs = 11739
                                                       Wald chi2(4)  =     .
                                                       Prob > chi2   =     .
                                                       R-squared     =     .
GMM weight matrix: Cluster (gvkey)                     Root MSE      = .49688

                                  (Std. Err. adjusted for 2288 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inv |
         LD. |   .2055418   .0237833     8.64   0.000     .1589275    .2521561
          cf |
         D1. |   .0311136   .0089249     3.49   0.000     .0136211    .0486061
           q |
         D1. |   .0482607   .0028293    17.06   0.000     .0427155     .053806
      Dts_cf |
         D1. |   .0093374   .0082895     1.13   0.260    -.0069097    .0255845
------------------------------------------------------------------------------
Instrumented:  LD.inv
Instruments:   D.cf D.q D.Dts_cf L2.inv L3.inv
```

c) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .789297 (p = 0.3743)
```

d) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv d.Dts_cf, robust noc

Linear regression                                      Number of obs = 11739
                                                     F(  5, 11734) =  301.53
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.2568
                                                     Root MSE      =  .41619

------------------------------------------------------------------------------
             |               Robust
      LD.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |
         D1. |  -.0227588   .0059513    -3.82   0.000    -.0344244   -.0110932
           q |
         D1. |  -.0239945   .0020537   -11.68   0.000    -.0280201    -.019969
         inv |
         L2. |  -.4886881   .0130346   -37.49   0.000     -.514238   -.4631381
         L3. |     .10085   .0049732    20.28   0.000     .0911017    .1105982
      Dts_cf |
         D1. |   .0017067   .0059832     0.29   0.775    -.0100213    .0134347
------------------------------------------------------------------------------

. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11734) =  703.23
            Prob > F =    0.0000
```

10. Test: Dividend and Total Assets Interacted

a) Fixed-effect Model:

```
. xtreg  inv cf q Ddiv_cf Dta_cf DX1, fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                           Number of groups   =      2825

R-sq:  within  = 0.6099                         Obs per group: min =         1
       between = 0.3140                                        avg =       7.3
       overall = 0.4748                                        max =        10

                                                F(5,17681)         =   5529.65
corr(u_i, Xb)  = -0.2462                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .2211761   .0024575    90.00   0.000     .2163592    .2259931
           q |   .0713408   .0016083    44.36   0.000     .0681884    .0744932
     Ddiv_cf |   .0684141    .010546     6.49   0.000     .0477428    .0890853
      Dta_cf |  -.0915262   .0028058   -32.62   0.000    -.0970259   -.0860265
         DX1 |  -.0308336   .0113938    -2.71   0.007    -.0531666   -.0085006
       _cons |  -.0075579   .0120068    -0.63   0.529    -.0310923    .0159766
-------------+----------------------------------------------------------------
     sigma_u |  .37506608
     sigma_e |  .44393041
         rho |  .41650653   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17681) =     3.97         Prob > F = 0.0000
```

b) Instrumental Variable by GMM:

```
Instrumental variables (GMM) regression               Number of obs = 11739
                                                      Wald chi2(6)  =      .
                                                      Prob > chi2   =      .
                                                      R-squared     =      .
GMM weight matrix: Cluster (gvkey)                    Root MSE      = .48709

                                (Std. Err. adjusted for 2288 clusters in gvkey)
------------------------------------------------------------------------------
             |               Robust
       D.inv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inv |
         LD. |   .1879015   .0224015     8.39   0.000     .1439953    .2318077
          cf |
         D1. |   .0191146   .0118968     1.61   0.108    -.0042028    .0424319
           q |
         D1. |   .0471591   .0027763    16.99   0.000     .0417176    .0526005
    Ddiv_cf  |
         D1. |   .0912642   .0089055    10.25   0.000     .0738096    .1087187
      Dta_cf |
         D1. |   .0083576   .0114163     0.73   0.464    -.0140179     .030733
         DX1 |  -.0078749   .0050378    -1.56   0.118    -.0177489     .001999
------------------------------------------------------------------------------
Instrumented:  LD.inv
Instruments:   D.cf D.q D.Ddiv_cf D.Dta_cf DX1 L2.inv L3.inv
```

c) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .676384 (p = 0.4108)
```

d) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv d.Ddiv_cf d.Dta_cf d.DX1, robust noc

Linear regression                                      Number of obs = 11739
                                                       F(  7, 11732) =  223.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2604
                                                       Root MSE      =  .41519

------------------------------------------------------------------------------
             |               Robust
      LD.inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |
         D1. |  -.0242593    .007749    -3.13   0.002    -.0394485    -.00907
           q |
         D1. |  -.0233268   .0021061   -11.08   0.000    -.0274552   -.0191985
         inv |
         L2. |  -.4912853   .0129204   -38.02   0.000    -.5166116   -.4659591
         L3. |   .1014753   .0049663    20.43   0.000     .0917405     .11121
     Ddiv_cf |
         D1. |  -.0503357   .0339135    -1.48   0.138    -.1168119    .0161404
      Dta_cf |
         D1. |   .0081485    .007535     1.08   0.280    -.0066214    .0229184
         DX1 |
         D1. |   .0159627   .0340701     0.47   0.639    -.0508204    .0827458
------------------------------------------------------------------------------

. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11732) =  723.40
            Prob > F =    0.0000
```

11. Test: Dividend and Sales Interacted

a) Fixed-effect Model:

```
. xtreg  inv cf q Ddiv_cf Dts_cf DX2, fe

Fixed-effects (within) regression               Number of obs      =     20511
Group variable: gvkey                           Number of groups   =      2825

R-sq:  within  = 0.5896                         Obs per group: min =         1
       between = 0.3491                                        avg =       7.3
       overall = 0.4654                                        max =        10

                                                F(5,17681)         =   5079.39
corr(u_i, Xb)  = -0.2747                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         inv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          cf |   .1715116   .0018625    92.09   0.000      .167861    .1751623
           q |   .0884047    .001549    57.07   0.000     .0853686    .0914409
     Ddiv_cf |   .0529573   .0095066     5.57   0.000     .0343235    .0715911
      Dts_cf |  -.0358918   .0025586   -14.03   0.000    -.0409069   -.0308768
         DX2 |  -.0201455   .0106048    -1.90   0.057     -.040932     .000641
       _cons |  -.1059075   .0118547    -8.93   0.000     -.129144    -.082671
-------------+----------------------------------------------------------------
     sigma_u |  .36587228
     sigma_e |  .45538282
         rho |  .39228718   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(2824, 17681) =     3.80         Prob > F = 0.0000
```

b) Instrumental Variable by GMM:

```
Instrumental variables (GMM) regression               Number of obs = 11739
                                                      Wald chi2(0)  =     .
                                                      Prob > chi2   =     .
                                                      R-squared     =     .
GMM weight matrix: Cluster (gvkey)                    Root MSE      = .48861

                          (Std. Err. adjusted for 2288 clusters in gvkey)
```

D.inv	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
inv						
LD.	.1942904	.0229453	8.47	0.000	.1493185	.2392623
cf						
D1.	.0306848	.008827	3.48	0.001	.0133841	.0479854
q						
D1.	.0470208	.0027306	17.22	0.000	.0416688	.0523727
Ddiv_cf						
D1.	.062415	.0397653	1.57	0.117	-.0155235	.1403536
Dts_cf						
D1.	-.0065572	.0087925	-0.75	0.456	-.0237901	.0106757
DX2						
D1.	.0307786	.0407359	0.76	0.450	-.0490622	.1106195

```
Instrumented:  LD.inv
Instruments:   D.cf D.q D.Ddiv_cf D.Dts_cf D.DX2 L2.inv L3.inv
```

c) J-test:

```
. estat overid

  Test of overidentifying restriction:

  Hansen's J chi2(1) = .904612 (p = 0.3415)
```

d) Test for Weak Instruments:

```
. regress dl.inv d.cf d.q l2.inv l3.inv d.Ddiv_cf d.Dts_cf d.DX2, robust noc

Linear regression                                  Number of obs = 11739
                                                 F(  7, 11732) =  224.36
                                                 Prob > F      =  0.0000
                                                 R-squared     =  0.2604
                                                 Root MSE      =   .4152
```

LD.inv	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
cf						
D1.	-.0223664	.005947	-3.76	0.000	-.0340235	-.0107093
q						
D1.	-.0236086	.0020735	-11.39	0.000	-.027673	-.0195442
inv						
L2.	-.49083	.0128981	-38.05	0.000	-.5161125	-.4655476
L3.	.1013803	.0049603	20.44	0.000	.0916574	.1111033
Ddiv_cf						
D1.	-.0369694	.0276325	-1.34	0.181	-.0911337	.017195
Dts_cf						
D1.	.0074421	.0059566	1.25	0.212	-.0042338	.0191181
DX2						
D1.	.0009648	.0280982	0.03	0.973	-.0541123	.0560418

```
. test l2.inv l3.inv

 ( 1)  L2.inv = 0
 ( 2)  L3.inv = 0

       F(  2, 11732) =  724.56
            Prob > F =    0.0000
```